IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

CISCO SYSTEMS, INC. and SCIENTIFIC-ATLANTA, INC., ARRIS GROUP, INC., and THOMSON, INC.,	)	
Plaintiffs,	)	
v.	)	C.A. No. 07-671 (SLR)
GPNE CORP.,	)	**JURY TRIAL DEMANDED**
Defendant.	)	

AMENDED COMPLAINT FOR DECLARATORY JUDGMENT

Plaintiffs CISCO SYSTEMS, INC., SCIENTIFIC-ATLANTA, INC., ARRIS GROUP, INC. and THOMSON, INC. (collectively, "Plaintiffs"), through their undersigned counsel, file this Amended Complaint against defendant GPNE CORP. ("GPNE") and seek declaratory relief with respect to U.S. Patent Nos. 6,282,406 (the "'2,406 Patent"); 7,200,406 (the "'0,406 Patent"); and 7,209,748 (the "'748 Patent") (collectively referred to as the "Patents-in-Suit"). In support of their Amended Complaint for Declaratory Judgment, Plaintiffs allege as follows:

The Parties

1. Cisco Systems, Inc. ("Cisco") is a California corporation with its principal place of business at 170 West Tasman Drive, San Jose, California 95134.

2. Scientific-Atlanta, Inc. ("SA") is a wholly-owned subsidiary of Cisco. SA is a Georgia corporation with its principal place of business at 5030 Sugarloaf Parkway, Lawrenceville, Georgia 30044-2869.

3. ARRIS Group, Inc. ("ARRIS") is a Delaware corporation with its principal place of business at 3871 Lakefield Drive, Suwanee, Georgia 30024.

4. Thomson, Inc. ("Thomson") is a Delaware corporation with its principal place of business at 101 W. 103rd Street, Indianapolis Indiana, 46290.

5. GPNE is a Delaware corporation. GPNE has the following registered agent in this judicial district: Corporation Services Company, 2711 Centerville Road, Suite 400, Wilmington, Delaware 19808. Upon information and belief, GPNE has its principal place of business at 2556 Lemon Road, Unit B101, Honolulu, Hawaii 96815.

6. GPNE purports to be the owner of each of the Patents-in-Suit, copies of which are attached hereto as Exhibits A-C.

Jurisdiction and Venue

7. This is an action for declaratory relief regarding United States patents.

8. This Court has jurisdiction over the subject matter of this action pursuant to 28 U.S.C. §§ 1331 and 1338(a), in that it involves claims arising under the United States Patent Act, 35 U.S.C.§ 1 *et seq.*

9. This Court may declare the rights and other legal relations of the parties pursuant to 28 U.S.C. §§ 2201 and 2202 because there is a case of actual controversy within the Court's jurisdiction.

10. This Court has personal jurisdiction over GPNE because, *inter alia*, GPNE is incorporated in this judicial district and has a registered agent in this judicial district.

11. Venue is proper in this judicial district pursuant to 28 U.S.C. § 1391.

The Presence Of An Actual Controversy

12. Cisco, SA, ARRIS and Thomson market, sell and offer to sell DOCSIS compliant cable modems to companies that own and operate cable systems. Purchasers of such DOCSIS compliant cable modems include Time Warner Cable Inc. ("TWC"), Comcast Cable Communications, LLC ("Comcast") and Charter Communications, Inc. ("Charter").

13. GPNE has asserted rights under the '2,406 Patent based on certain identified ongoing activity of Plaintiffs' customers.

14. GPNE has recently dismissed without prejudice an action alleging that each of TWC, Comcast and Charter infringe the `2,406 Patent by, *inter alia*, using and selling DOCSIS compliant cable modems. GPNE filed an amended complaint in that action and alleged that, "on information and belief," each of TWC, Comcast and Charter, "manufactures, uses, and sells products that infringe at least claim 1 of the '406 patent, including for example and without limitation all DOCSIS certified cable modems …."

15. In the course of that action, GPNE served infringement contentions specifically alleging that DOCSIS compliant cable modems used by TWC infringe the '2,406 Patent. GPNE's infringement contentions identified as "Accused Products" specific models of DOCSIS compliant cable modems, as well as "any other cable modems or other devices acting or capable of acting under the DOCSIC [sic] standard, or in the manner described and claimed in the '406 patent, as infringing the '406 patent."

16. Accordingly, GPNE has accused Plaintiffs' DOCSIS compliant cable modems of infringing the `2,406 Patent.

17. GPNE has also informed Cisco and SA that the DOCSIS compliant cable modems necessarily infringe the `2,406 Patent.

18. GPNE has also informed Cisco, SA and ARRIS that it is considering enforcing the `0,406 Patent and the `748 Patent against the DOCSIS compliant cable modems manufactured and sold by them.

19. GPNE has specifically informed Cisco, SA and ARRIS that payment of a substantial fee to GPNE can eliminate their exposure to GPNE's claims of infringement under the Patents-in-Suit with respect to DOCSIS compliant cable modems.

20. In the course of its litigation activities, GPNE sought damages and other relief against TWC, Comcast and Charter stemming from their use of DOCSIS compliant cable modems.

21. Plaintiffs believe DOCSIS compliant cable modems do not infringe any valid claim of the Patents-in-Suit, and further believe that they should be free to make, use, sell offer to sell and/or import DOCSIS compliant cable modems without taking a license from or paying fees to GPNE.

22. GPNE's threats and its litigation conduct place Plaintiffs under reasonable apprehension of suit.

23. Based on the foregoing, an actual and justiciable controversy exists between Plaintiffs and GPNE with respect to the infringement and validity of the Patents-in-Suit.

Count I: Declaration of Rights Regarding
U.S. Patent No. 6,282,406 (the "`2,406 Patent")

24. Plaintiffs restate and incorporate by reference each of the allegations of paragraphs 1-17 above.

25. GPNE claims to be the owner of all legal rights, title and interests in the `2,406 Patent, including the right to enforce the `2,406 Patent.

26. Plaintiffs have not and do not infringe – directly, contributorily, or by inducement – any valid claim of the `2,406 Patent.

27. Plaintiffs seek and are entitled to a declaration of non-infringement of the `2,406 Patent and/or invalidity of the `2,406 Patent pursuant to Title 35 of the United States Code.

Count II: Declaration of Rights Regarding
U.S. Patent No. 7,200,406 (the "`0,406 Patent")

28. Plaintiffs restate and incorporate by reference each of the allegations of paragraphs 1-21 above.

29. GPNE claims to be the owner of all legal rights, title and interests in the `0,406 Patent, including the right to enforce the `0,406 Patent.

30. The `0,406 Patent is a continuation of, *inter alia*, the `2,406 Patent.

31. Plaintiffs have not and do not infringe – directly, contributorily, or by inducement - any valid claim of the `0,406 Patent.

32. Plaintiffs seek and are entitled to a declaration of non-infringement of the `0,406 Patent and/or invalidity of the `0,406 Patent pursuant to Title 35 of the United States Code.

Count III: Declaration of Rights Regarding
U.S. Patent No. 7,209,748 the ("`784 Patent")

33. Plaintiffs restate and incorporate by reference each of the allegations of paragraphs 1-26 above.

34. GPNE claims to be the owner of all legal rights, title and interests in the `748 Patent, including the right to enforce the `748 Patent.

35. The `748 Patent is a continuation of *inter alia* the `2,406 Patent.

36. Plaintiffs have not and do not infringe - directly, contributorily, or by inducement - any valid claim of the `748 Patent.

37. Plaintiffs seek and are entitled to a declaration of non-infringement of the `748 Patent and/or invalidity of the `748 patent pursuant to title 35 of the United States Code.

Prayer for Relief

WHEREFORE, Plaintiffs pray:

(a) That this Court find and declare that Plaintiffs' DOCSIS compliant cable modems do not infringe and have not infringed, in any manner, the Patents-in-Suit and/or that the Patents-in-Suit are invalid pursuant to Title 35 of the United States Code;

(b) That this Court award Plaintiffs all of their costs of this action;

(c) That this Court find that this is an exceptional case and award Plaintiffs their attorneys' fees pursuant to 35 U.S.C. § 285 or otherwise; and

(d) That this Court grant Plaintiffs such other and further relief as the court deems just and proper.

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Cisco Systems, Inc., Scientific-Atlanta, Inc.,
ARRIS Group, Inc. and Thomson, Inc.

December 4, 2007
1327987

CERTIFICATE OF SERVICE

I, the undersigned, hereby certify that on December 4, 2007, copies of the foregoing were caused to be served upon the following in the manner indicated:

BY HAND

GPNE Corp.
c/o Corporation Service Company
2711 Centerville Road
Wilmington, DE 19808

/s/ Karen Jacobs Louden

klouden@mnat.com (#2881)

EXHIBIT A

US006282406B1

(12) **United States Patent**
Wong et al.

(10) **Patent No.: US 6,282,406 B1**
(45) **Date of Patent: *Aug. 28, 2001**

(54) **PAGING METHOD AND APPARATUS**

(75) Inventors: **Gabriel K. Wong; Po S. Tsui**, both of Honolulu, HI (US)

(73) Assignee: **Digicomm, Ltd.**, Honolulu, HI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/594,662**

(22) Filed: **Jun. 15, 2000**

Related U.S. Application Data

(63) Continuation of application No. 08/264,973, filed on Jun. 24, 1994, now Pat. No. 5,542,115.

(51) **Int. Cl.**[7] **H04B 7/00**
(52) **U.S. Cl.** **455/31.3**
(58) **Field of Search** 455/38.1, 38.4, 455/31.1, 31.2, 31.3, 509, 510, 515, 517, 224; 340/825.44, 825.2; 370/330, 336, 350, 436, 450

(56) **References Cited**

U.S. PATENT DOCUMENTS

Re. 32,365	5/1987	Sebestyen .
Re. 33,417	10/2000	Bhagat et al. .
4,224,150	9/1980	Neustein .
4,345,491	8/1992	Fascenda et al. .
4,644,347	2/1987	Lucas et al. .
4,644,351	2/1987	Zabarsky et al. .
4,713,808	12/1987	Gaskill et al. .
4,747,122	5/1988	Bhagat et al. .
4,823,123	4/1989	Siwiak .
4,845,491	7/1989	Fascenda et al. .
4,870,402	9/1989	DeLuca et al. .
4,875,038	10/1989	Siwiak et al. .
4,882,579	11/1989	Siwiak .
4,914,649	4/1990	Schwendeman et al. .
4,940,963	7/1990	Gutman et al. .
4,978,944	12/1990	Andros et al. .
5,043,721	8/1991	May .
5,086,501	2/1992	DeLuca et al. .
5,109,400	4/1992	Patsiokas et al. .
5,111,197	5/1992	Ichikawa .
5,117,449	5/1992	Metroka et al. .
5,142,279	8/1992	Jasinski et al. .
5,153,582	10/1992	Davis .
5,170,487	12/1992	Peek .
5,206,855	4/1993	Schwendeman et al. .
5,224,150	6/1993	Neustein .
5,247,700	9/1993	Wohl et al. .
5,260,986	11/1993	Pershan .
5,285,496	2/1994	Frank et al. .

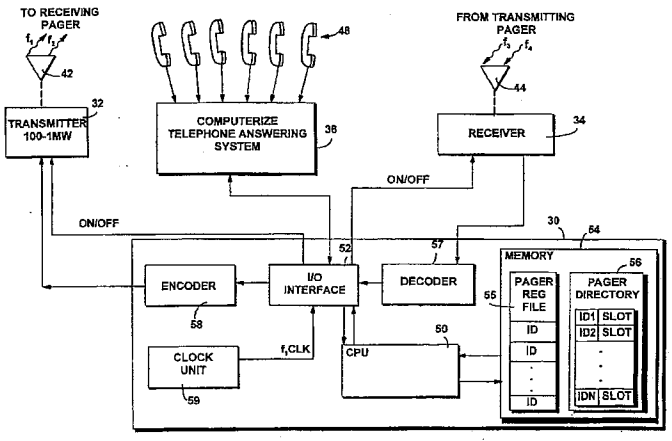
(List continued on next page.)

Primary Examiner—Thanh Cong Le
(74) *Attorney, Agent, or Firm*—Beyer Weaver & Thomas, LLP

(57) **ABSTRACT**

A two-way paging system utilizes four local frequencies for transmissions between pager units (**22**) and a central control station (**20**). A first local frequency (f_1) carries a local clock; a second local frequency (f_2) carries communications packets from the central control station to paging units; a third local frequency (f_3) carries communication packets from the pager units to the central control station; and a fourth local frequency (f_4) carries a status or request signal from the paging units (**22**) to the central control station (**20**). Transmissions on the fourth local frequency (f_4) are in accordance with a time divided slot allocation among pager units accessing the central control station (**20**). For a two-way paging system having a plurality of central control stations (420_x) servicing a corresponding plurality of cells, a total of eight frequencies are utilized within any one cell. Four of the utilized frequencies are the local frequencies (f_1–f_4) [which may differ from cell to cell], and four of the utilized frequencies are lower power common frequencies or switching frequencies (C_1–C_4) which are used to switch or handoff a pager unit (**422**) traveling from one cell to another.

16 Claims, 13 Drawing Sheets



U.S. PATENT DOCUMENTS

5,396,496		3/1995	Ito et al. .			
5,396,537		3/1995	Schwendenman et al. .			
5,463,675		10/1995	Gerszberg .			
5,485,463		1/1996	Godoroja .			
5,491,469		2/1996	Schwendeman .			
5,542,115	*	7/1996	Wong	455/507		
5,689,807	*	11/1997	Wong et al.	455/38.1		

* cited by examiner

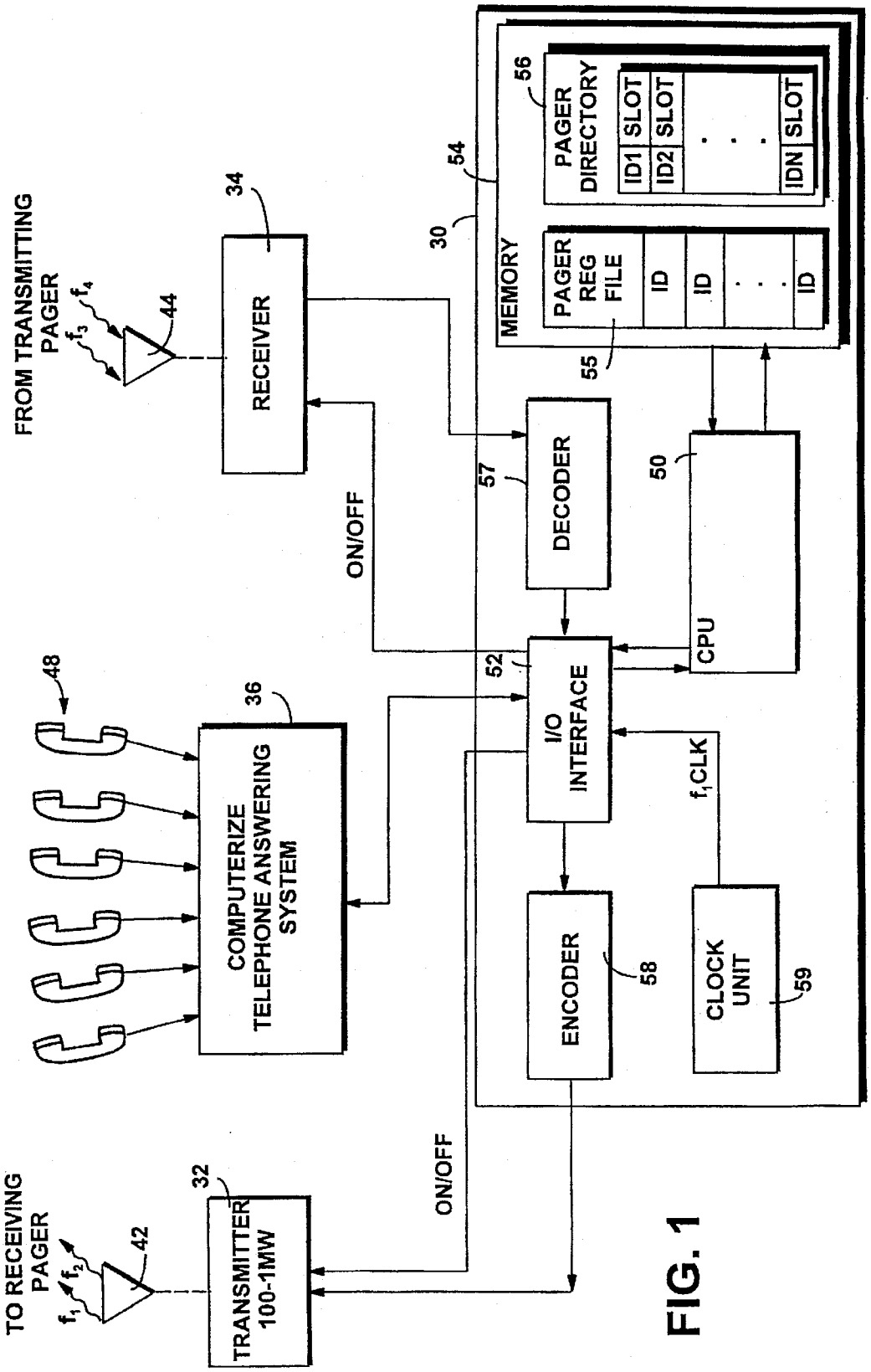

FROM TRANSMITTING PAGER
f_3 f_4
44
RECEIVER
34
30
MEMORY
54
PAGER DIRECTORY
56
ID1 SLOT
ID2 SLOT
IDN SLOT
PAGER REG FILE
ID
ID
ID
55
ON/OFF
DECODER
57
50
CPU
48
36
COMPUTERIZE TELEPHONE ANSWERING SYSTEM
52
I/O INTERFACE
f_1CLK
ENCODER
58
CLOCK UNIT
59
ON/OFF
TO RECEIVING PAGER
f_1 f_2
42
32
TRANSMITTER 100-1MW

FIG. 1

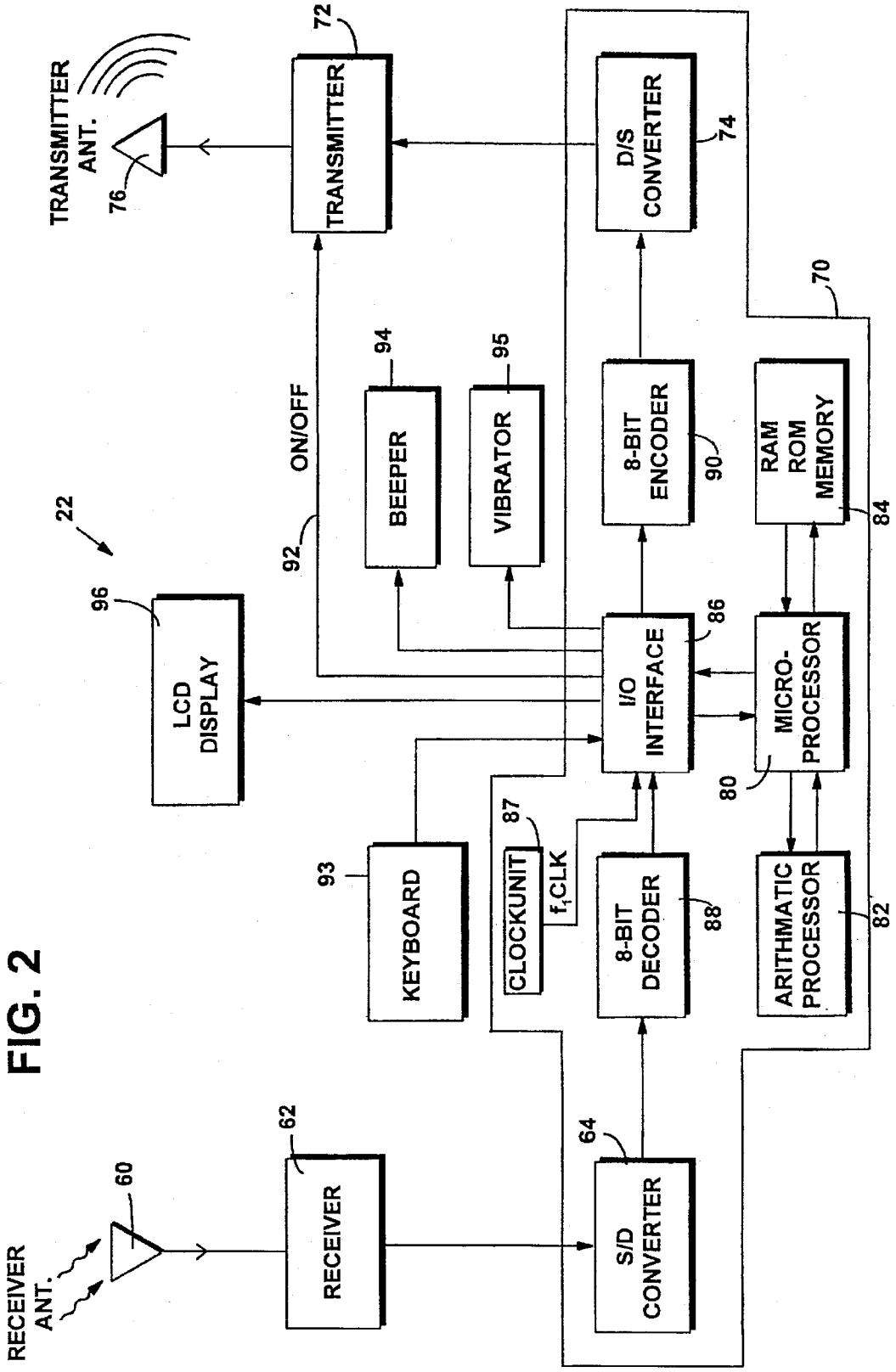
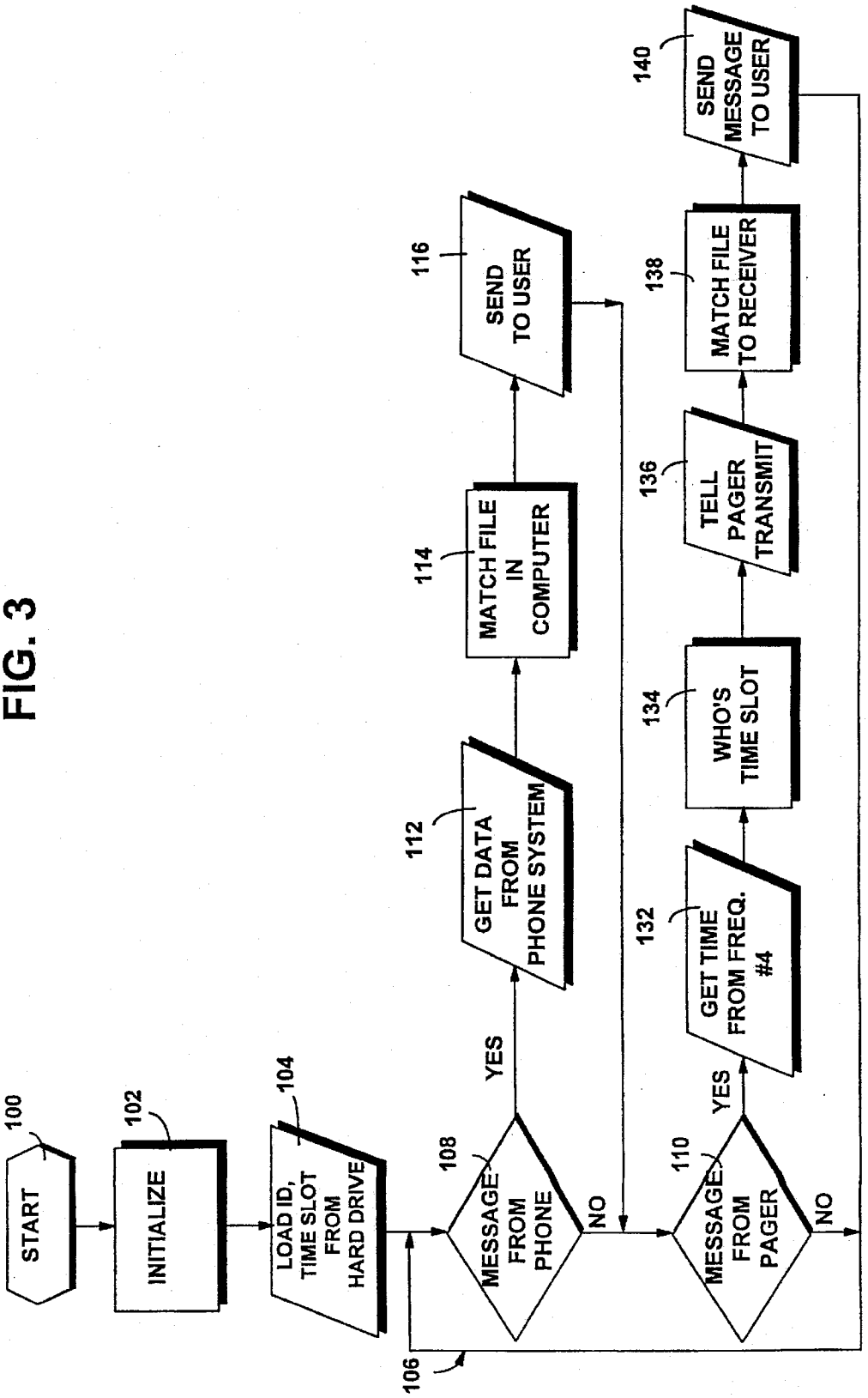

TRANSMITTER ANT.
76
72
TRANSMITTER
D/S CONVERTER
74
70
94
95
BEEPER
VIBRATOR
ON/OFF
92
8-BIT ENCODER
90
RAM ROM MEMORY
84
22
96
LCD DISPLAY
I/O INTERFACE
86
MICRO-PROCESSOR
80
87
CLOCKUNIT
f,CLK
93
KEYBOARD
8-BIT DECODER
88
ARITHMATIC PROCESSOR
82
62
64
60
RECEIVER ANT.
RECEIVER
S/D CONVERTER

FIG. 2

FIG. 3


START
100
INITIALIZE
102
LOAD ID, TIME SLOT FROM HARD DRIVE
104
MESSAGE FROM PHONE
108
YES
NO
GET DATA FROM PHONE SYSTEM
112
MATCH FILE IN COMPUTER
114
SEND TO USER
116
MESSAGE FROM PAGER
110
YES
NO
GET TIME FROM FREQ. #4
132
WHO'S TIME SLOT
134
TELL PAGER TRANSMIT
136
MATCH FILE TO RECEIVER
138
SEND MESSAGE TO USER
140
106

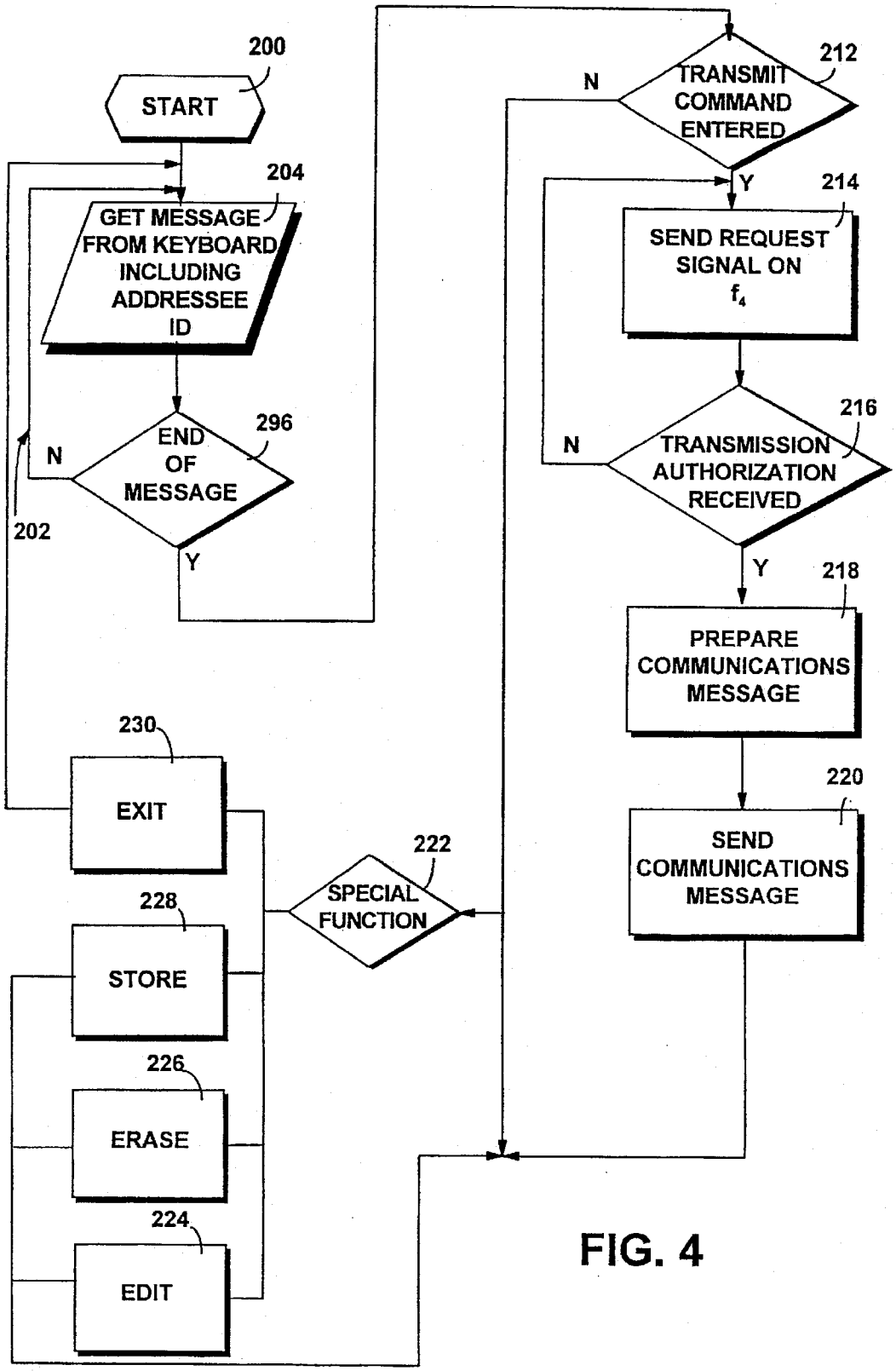

200
START
204
GET MESSAGE FROM KEYBOARD INCLUDING ADDRESSEE ID
296
END OF MESSAGE
N
Y
202
212
TRANSMIT COMMAND ENTERED
N
Y
214
SEND REQUEST SIGNAL ON f_4
216
TRANSMISSION AUTHORIZATION RECEIVED
N
Y
218
PREPARE COMMUNICATIONS MESSAGE
220
SEND COMMUNICATIONS MESSAGE
222
SPECIAL FUNCTION
230
EXIT
228
STORE
226
ERASE
224
EDIT

FIG. 4

FIG. 5

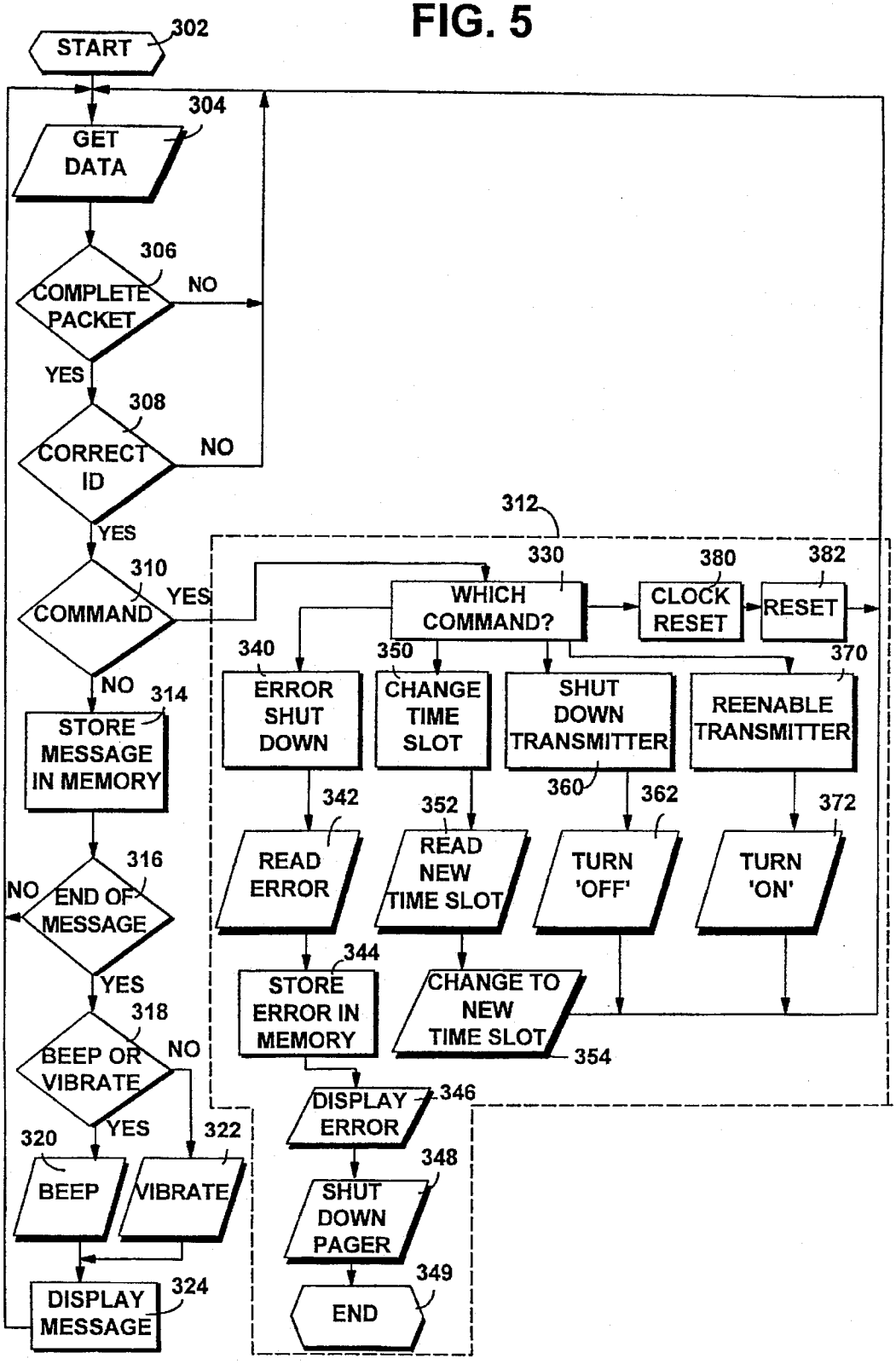

START
302
GET DATA
304
COMPLETE PACKET
306
NO
YES
CORRECT ID
308
NO
YES
COMMAND
310
YES
NO
STORE MESSAGE IN MEMORY
314
END OF MESSAGE
316
NO
YES
BEEP OR VIBRATE
318
NO
YES
BEEP
320
VIBRATE
322
DISPLAY MESSAGE
324
312
WHICH COMMAND?
330
CLOCK RESET
380
RESET
382
ERROR SHUT DOWN
340
CHANGE TIME SLOT
350
SHUT DOWN TRANSMITTER
360
REENABLE TRANSMITTER
370
READ ERROR
342
READ NEW TIME SLOT
352
TURN 'OFF'
362
TURN 'ON'
372
STORE ERROR IN MEMORY
344
CHANGE TO NEW TIME SLOT
354
DISPLAY ERROR
346
SHUT DOWN PAGER
348
END
349

FIG. 6

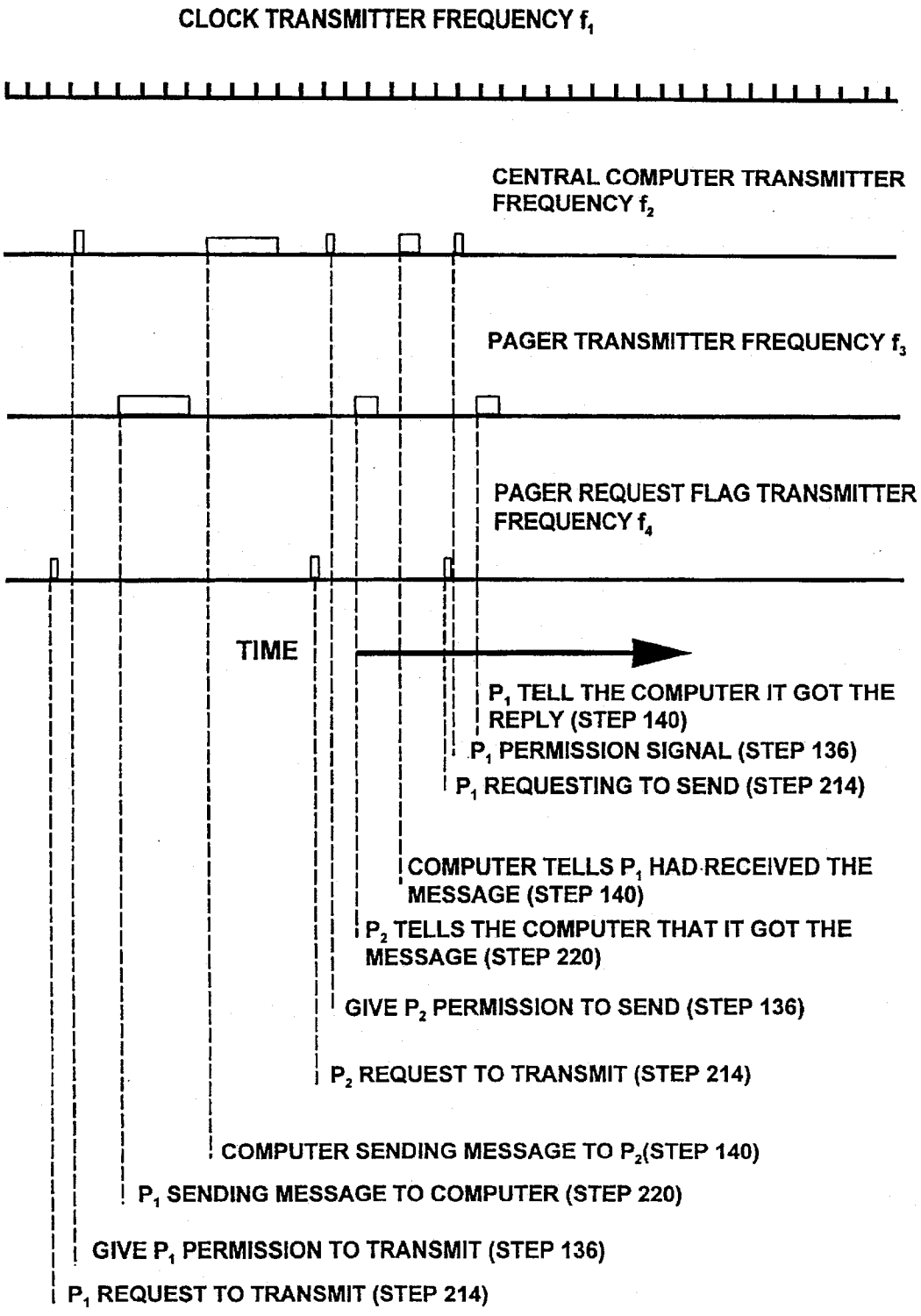

CLOCK TRANSMITTER FREQUENCY f_1
CENTRAL COMPUTER TRANSMITTER FREQUENCY f_2
PAGER TRANSMITTER FREQUENCY f_3
PAGER REQUEST FLAG TRANSMITTER FREQUENCY f_4
TIME
P_1 TELL THE COMPUTER IT GOT THE REPLY (STEP 140)
P_1 PERMISSION SIGNAL (STEP 136)
P_1 REQUESTING TO SEND (STEP 214)
COMPUTER TELLS P_1 HAD RECEIVED THE MESSAGE (STEP 140)
P_2 TELLS THE COMPUTER THAT IT GOT THE MESSAGE (STEP 220)
GIVE P_2 PERMISSION TO SEND (STEP 136)
P_2 REQUEST TO TRANSMIT (STEP 214)
COMPUTER SENDING MESSAGE TO P_2(STEP 140)
P_1 SENDING MESSAGE TO COMPUTER (STEP 220)
GIVE P_1 PERMISSION TO TRANSMIT (STEP 136)
P_1 REQUEST TO TRANSMIT (STEP 214)

FIG. 7

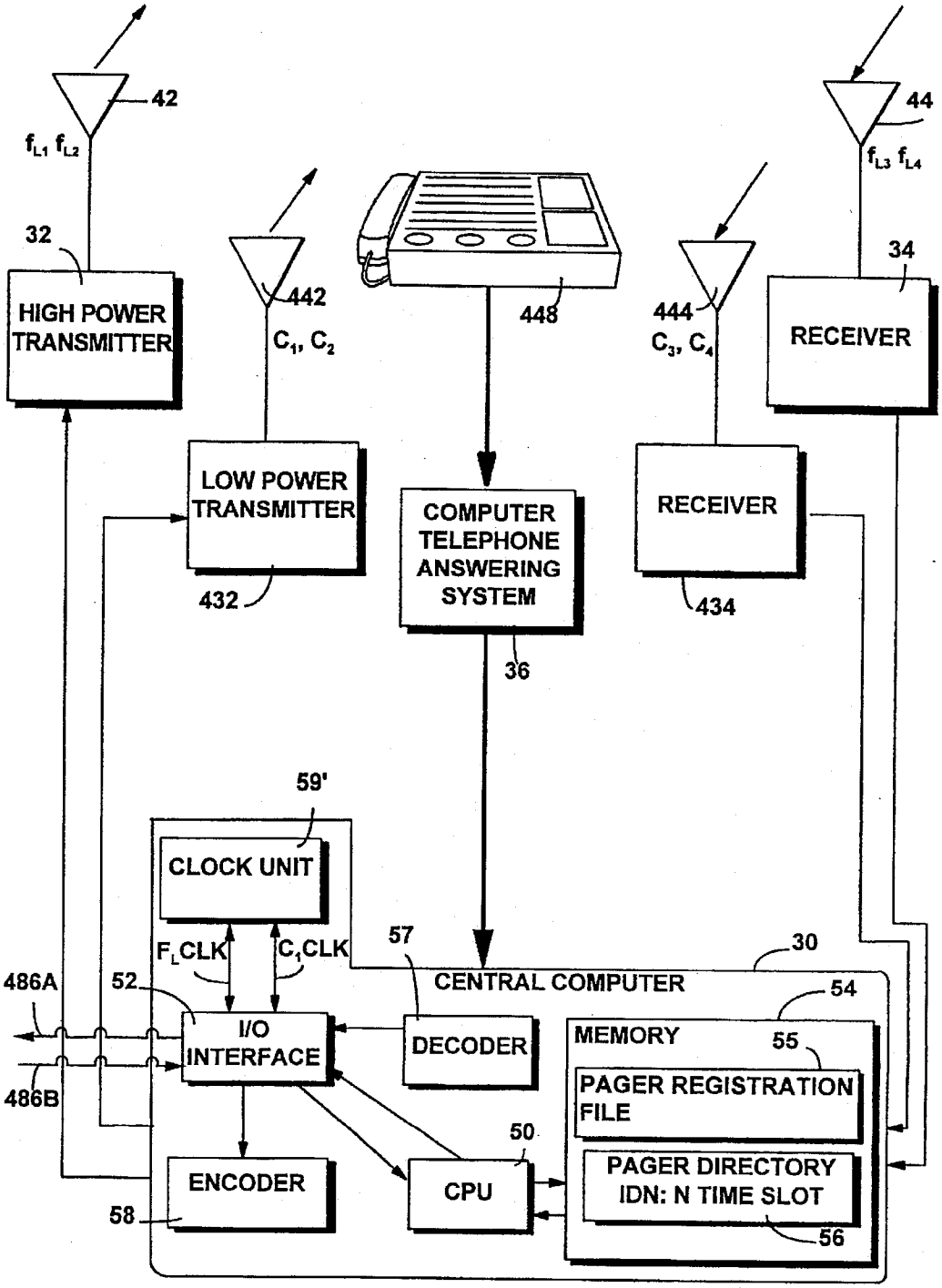

42
f_{L1} f_{L2}
32
HIGH POWER TRANSMITTER
442
C_1, C_2
LOW POWER TRANSMITTER
432
448
COMPUTER TELEPHONE ANSWERING SYSTEM
36
444
C_3, C_4
RECEIVER
434
44
f_{L3} f_{L4}
34
RECEIVER
59'
CLOCK UNIT
F_LCLK
C_1CLK
57
30
CENTRAL COMPUTER
54
486A
52
I/O INTERFACE
DECODER
MEMORY
55
PAGER REGISTRATION FILE
486B
50
ENCODER
CPU
PAGER DIRECTORY IDN: N TIME SLOT
58
56

FIG. 8

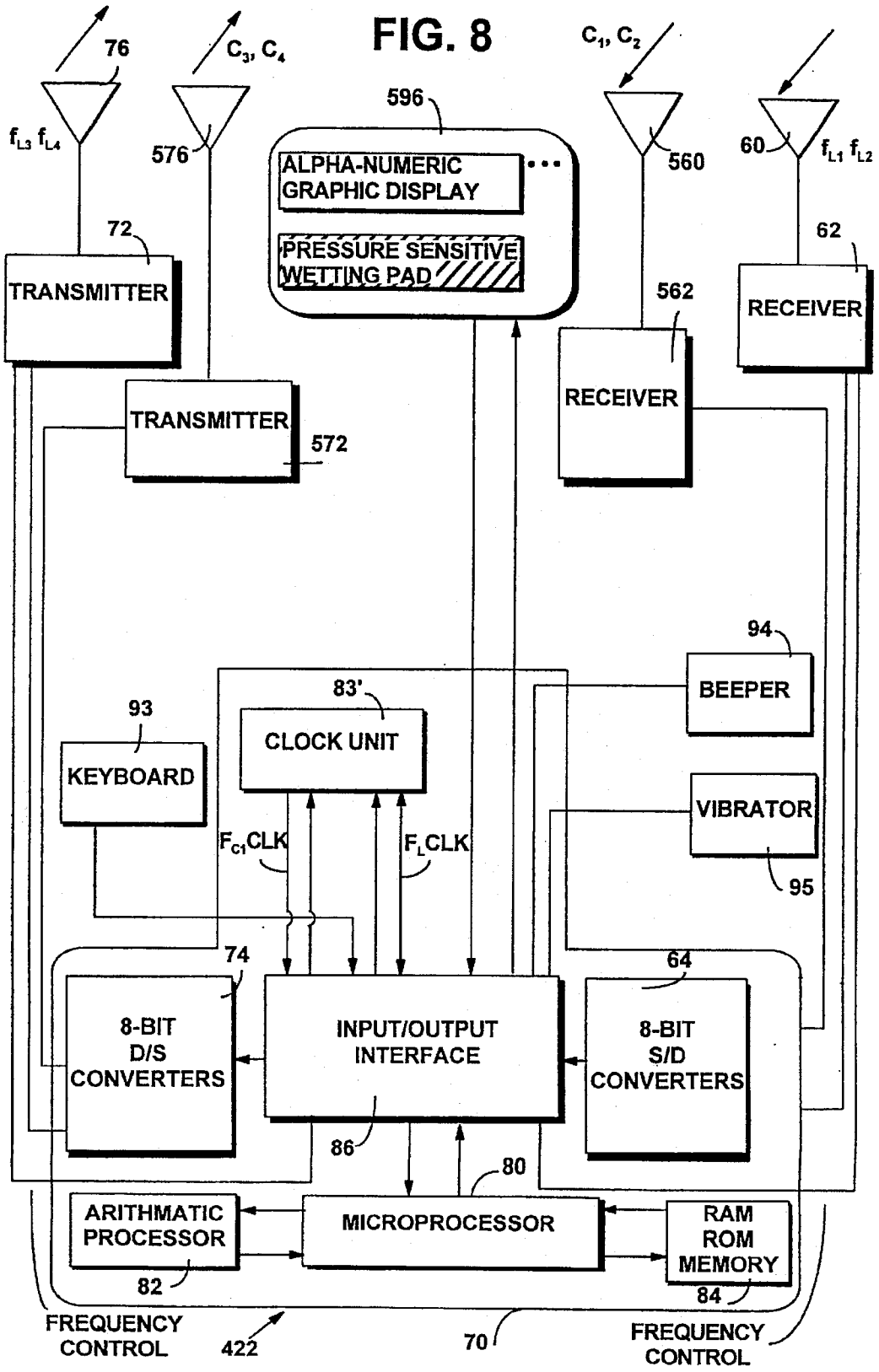
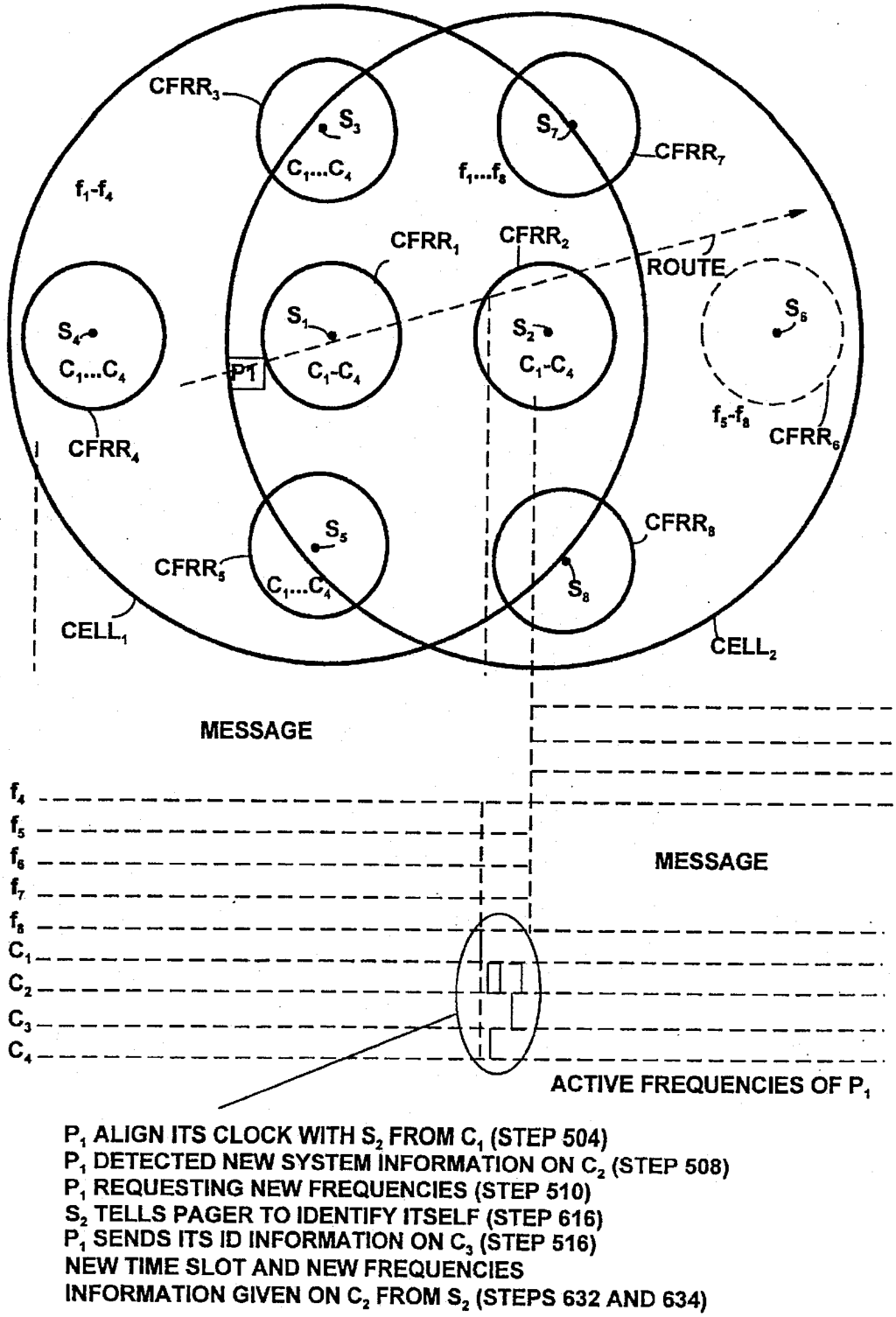

76
C_3, C_4
C_1, C_2
596
60
f_{L3} f_{L4}
576
560
f_{L1} f_{L2}
ALPHA-NUMERIC GRAPHIC DISPLAY
PRESSURE SENSITIVE WETTING PAD
72
62
TRANSMITTER
562
RECEIVER
RECEIVER
TRANSMITTER
572
94
BEEPER
83'
93
CLOCK UNIT
KEYBOARD
VIBRATOR
F_{C1}CLK
F_LCLK
95
74
64
8-BIT D/S CONVERTERS
INPUT/OUTPUT INTERFACE
8-BIT S/D CONVERTERS
86
80
ARITHMATIC PROCESSOR
MICROPROCESSOR
RAM ROM MEMORY
82
84
FREQUENCY CONTROL
422
70
FREQUENCY CONTROL

FIG. 9



P1 ALIGN ITS CLOCK WITH S2 FROM C1 (STEP 504)
P1 DETECTED NEW SYSTEM INFORMATION ON C2 (STEP 508)
P1 REQUESTING NEW FREQUENCIES (STEP 510)
S2 TELLS PAGER TO IDENTIFY ITSELF (STEP 616)
P1 SENDS ITS ID INFORMATION ON C3 (STEP 516)
NEW TIME SLOT AND NEW FREQUENCIES
INFORMATION GIVEN ON C2 FROM S2 (STEPS 632 AND 634)

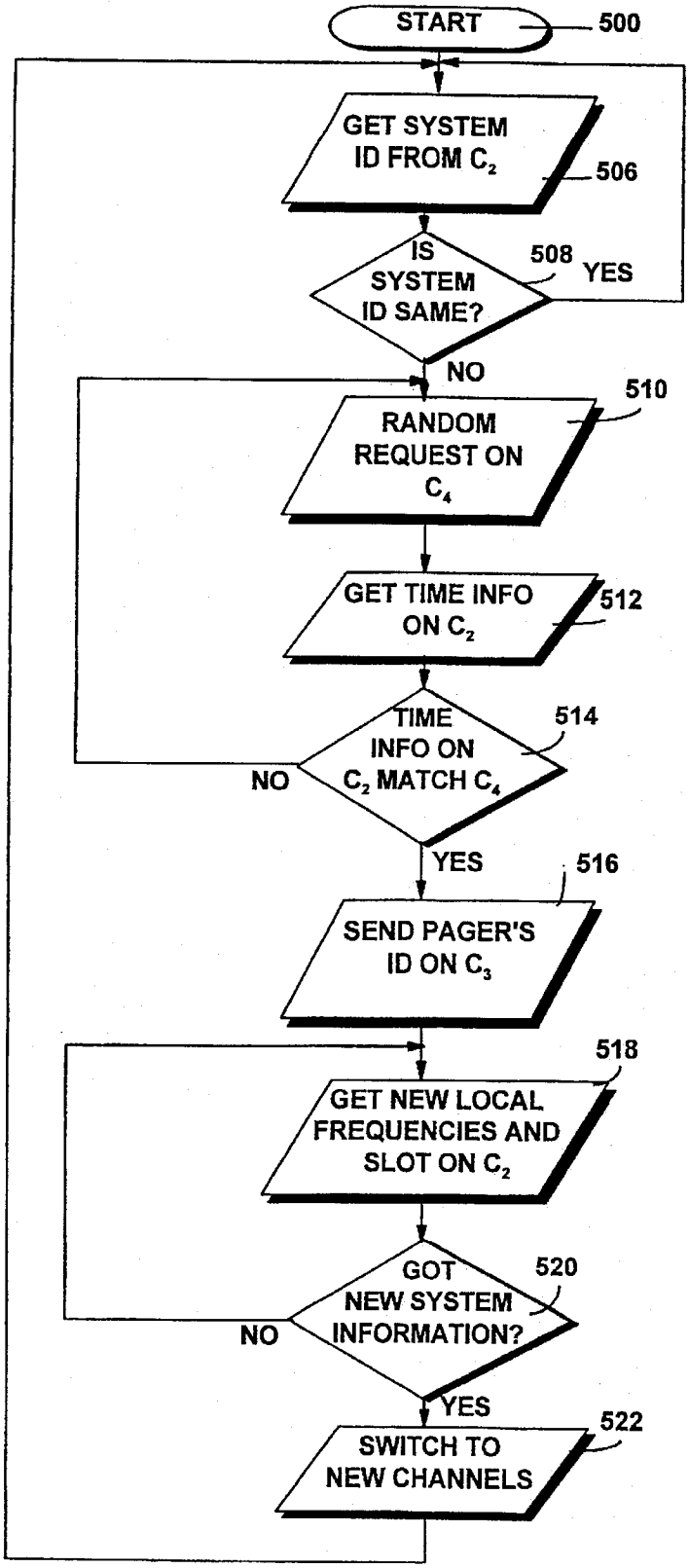
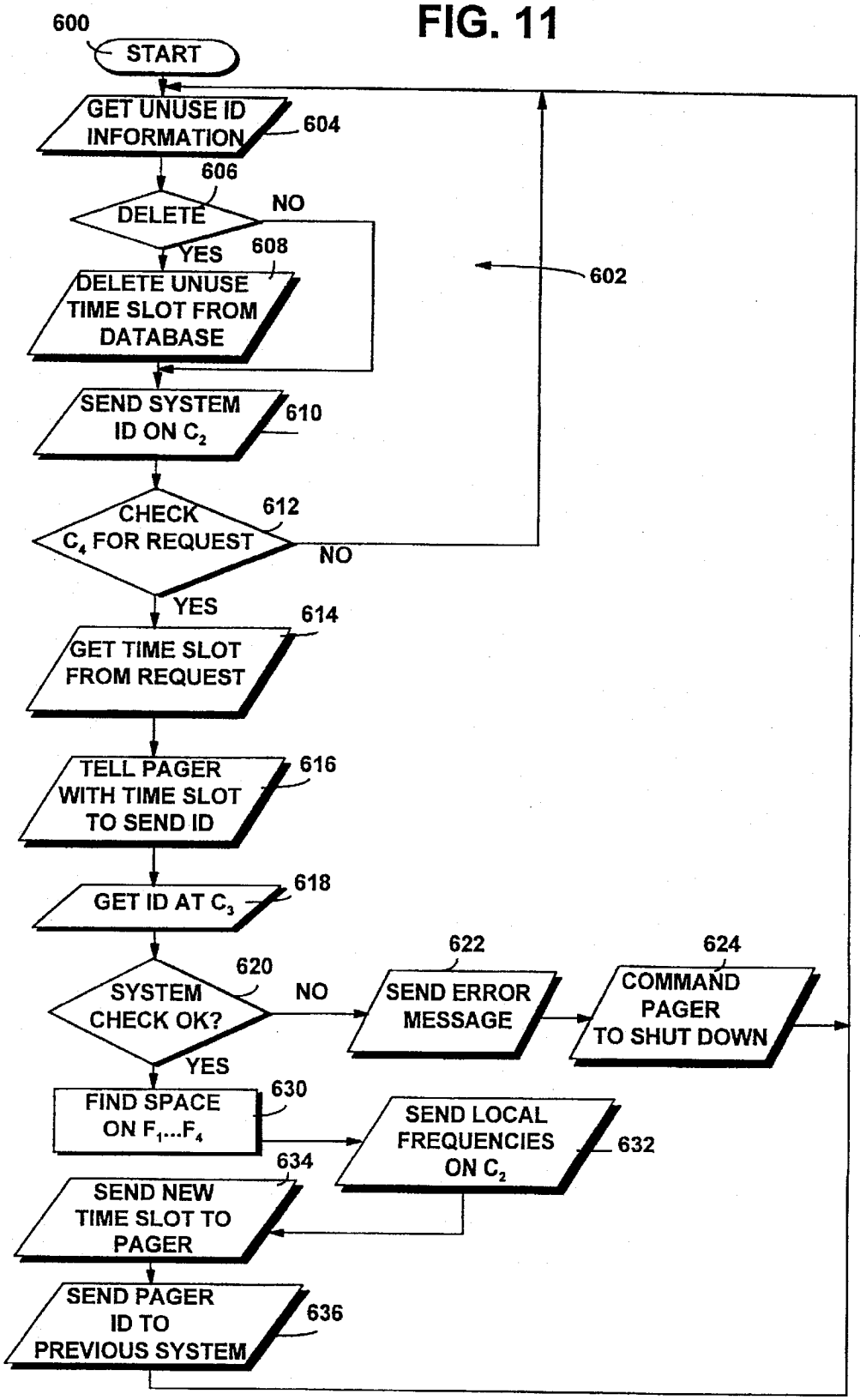

START
500
GET SYSTEM ID FROM C_2
506
IS SYSTEM ID SAME?
508
YES
NO
RANDOM REQUEST ON C_4
510
GET TIME INFO ON C_2
512
TIME INFO ON C_2 MATCH C_4
514
NO
YES
SEND PAGER'S ID ON C_3
516
GET NEW LOCAL FREQUENCIES AND SLOT ON C_2
518
GOT NEW SYSTEM INFORMATION?
520
NO
YES
SWITCH TO NEW CHANNELS
522

FIG. 10

FIG. 11


600
START
GET UNUSE ID INFORMATION
604
606
DELETE
NO
YES
608
DELETE UNUSE TIME SLOT FROM DATABASE
602
SEND SYSTEM ID ON C_2
610
CHECK C_4 FOR REQUEST
612
NO
YES
614
GET TIME SLOT FROM REQUEST
TELL PAGER WITH TIME SLOT TO SEND ID
616
GET ID AT C_3
618
SYSTEM CHECK OK?
620
NO
622
SEND ERROR MESSAGE
624
COMMAND PAGER TO SHUT DOWN
YES
FIND SPACE ON F_1...F_4
630
SEND LOCAL FREQUENCIES ON C_2
632
SEND NEW TIME SLOT TO PAGER
634
SEND PAGER ID TO PREVIOUS SYSTEM
636

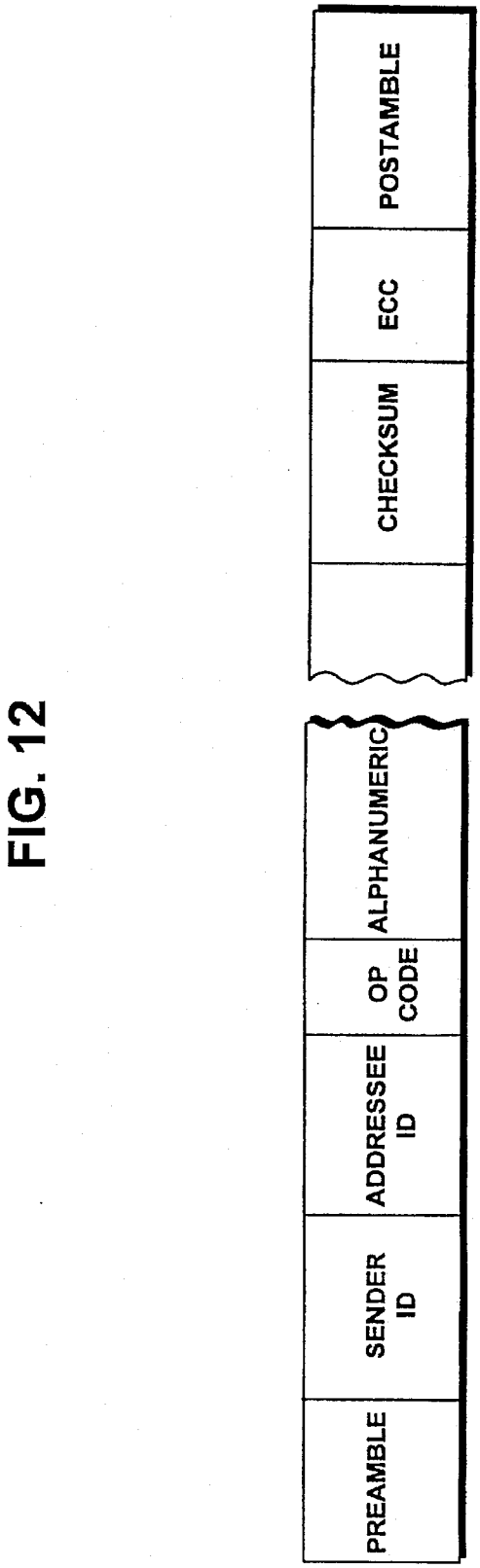
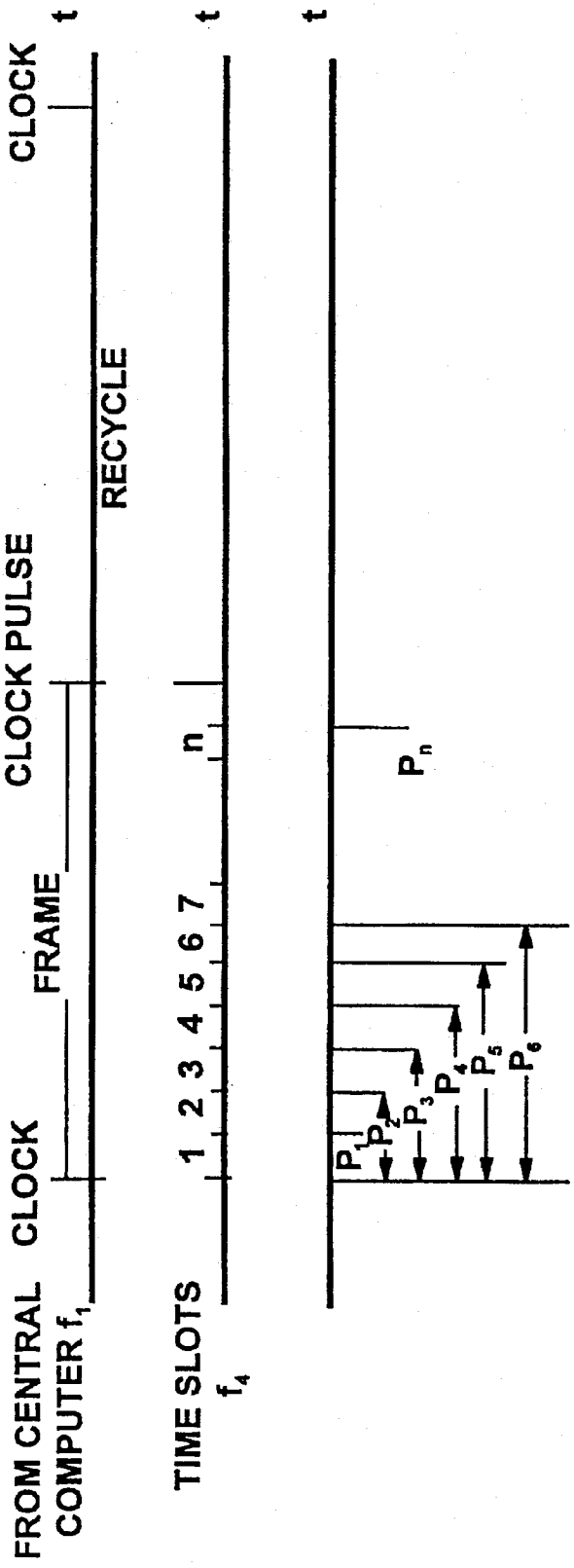

PREAMBLE
SENDER ID
ADDRESSEE ID
OP CODE
ALPHANUMERIC
CHECKSUM
ECC
POSTAMBLE

FIG. 12

FIG. 13


FROM CENTRAL COMPUTER f_1
CLOCK
FRAME
CLOCK PULSE
RECYCLE
TIME SLOTS
f_4
1 2 3 4 5 6 7
n
t
t
t
P_1
P_2
P_3
P_4
P_5
P_6
P_n

PAGING METHOD AND APPARATUS

This is a continuation of application Ser. No. 08/264,973, filed Jun. 24, 1994, now U.S. Pat. No. 5,542,115, issued Jul. 30, 1996, entitled "PAGING METHOD AND APPARATUS", naming Wong et al. as inventors.

RELATED APPLICATION DATA

The present application also relates to a number of commonly assigned, copending U.S. patent applications, including U.S. patent application Ser. No. 08/609,976, filed on Feb. 29, 1996, now U.S. Pat. No. 5,689,807, issued Nov. 18, 1997, entitled "PAGING METHOD AND APPARATUS", naming Wong et al. as inventors; U.S. patent application Ser. No. 08/608,629, filed on Feb. 29, 1996, now U.S. Pat. No. 5,729,827, issued Mar. 17, 1998 entitled "PAGER WITH STATION SWITCH REQUEST", naming Wong et al. as inventors; U.S. patent application Ser. No. 08/609,978, filed on Feb. 29, 1996, now U.S. Pat. No. 5,613,212, issued Mar. 18, 1997 entitled "PAGING METHOD AND APPARATUS", naming Wong et al. as inventors; and U.S. patent application Ser. No. 09/259,417, filed on Dec. 9, 1997, entitled "PAGING METHOD AND APPARATUS", naming Wong et al. as inventors. Each of the disclosures of these applications is incorporated herein by reference in its entirety for all purposes.

BACKGROUND

1. Field of Invention

This invention pertains to communications paging, and particularly to two-way paging method and apparatus.

2. Related Art and Other Considerations

Over the last several decades, pagers have proven to be important communication devices for contacting remotely situated personnel. Whereas primitive pagers provided primarily only a tonal and/or vibratory output, more modern pagers have enhanced output capabilities such as message-bearing alphanumeric displays.

Paging systems have historically been one-way systems. That is, the user receives a paging message from a central terminal but has no way of responding to that message with the pager. Prior art attempts to provide two-way communication capabilities for a pager have included efforts to connect the pager to a telephone (e.g., to a mobile radio telephone). See, for example, U.S. Pat. No. RE 33,417 to Bhagat et al. (which combines an entire radio pager and radiotelephone linked through an automatic dialer) and U.S. Pat. No. 5,117,449 to Metroka, et. al. (which purports to combine paging and cellular radiotelephone functions in a single unit).

Some pagers have the capability of providing an acknowledgment or response to a paging signal. In some such "ack-back" systems, a user operates a reply input device (e.g., a toggle switch, pushbutton switch, or keyboard) when paged. Typically such ack-back systems involve a complex acknowledgement transmission scheme, involving numerous frequencies or frequency sub-bands. Hand-off of the pager, as the pager travels between differing geographic regions or "cells" served by differing central stations, becomes technically cumbersome when multitudinous frequencies are involved.

SUMMARY

A two-way paging system utilizes four local frequencies for transmissions between pager units and a central control station. A first local frequency carries a local clock; a second local frequency carries communications packets from the central control station to paging units; a third local frequency carries communication packets from the pager units to the central control station; and a fourth local frequency carries a status or request signal from the paging units to the central control station. Transmissions on the fourth local frequency are in accordance with a time divided slot allocation among pager units accessing the central control station.

For a two-way paging system having a plurality of central control stations servicing a corresponding plurality of cells, a total of eight frequencies are utilized within any one cell. Four of the utilized frequencies are the local frequencies, (which may differ from cell to cell), and four of the utilized frequencies are lower power common frequencies or switching frequencies which are used to switch or hand-off a pager unit traveling from one cell to another.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. **1** is a schematic view of a central control station included in a paging system of an embodiment of the invention.

FIG. **2** is a schematic view of a pager unit included in a paging system for use with the central control station of FIG. **1**.

FIG. **3** is a flowchart depicting steps executed by the central control station of FIG. **1**.

FIG. **4** is a flowchart depicting steps executed by the pager unit of FIG. **2** when in a transmit mode.

FIG. **5** is a flowchart depicting steps executed by the pager unit of FIG. **2** when in a receive mode.

FIG. **6** is a timing diagram reflecting communications between the central control station of FIG. **1** and the pager unit of FIG. **2**.

FIG. **7** is a schematic view of a central control station included in a paging system of a second embodiment of the invention.

FIG. **8** is a schematic view of a pager unit included in a paging system for use with the central control station of FIG. **7**.

FIG. **9** is a hybrid schematic view and timing diagram for representing switching operations for the paging system of the second embodiment of the invention.

FIG. **10** is a flowchart depicting steps executed by the pager unit of FIG. **8** in connection with a channel switching operation.

FIG. **11** is a flowchart depicting steps executed by the central control station of FIG. **7** in connection with a channel switching operation.

FIG. **12** is a schematic view of a format of a communications packet utilized with embodiments of the invention.

FIG. **13** is a schematic view illustrating a time divided slot allocation technique according to the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a central control station **20** according to a first embodiment of the invention; FIG. **2** shows a paging unit **22** suitable for use with central control station **20**.

As shown in FIG. **1**, central control station **20** includes central computer **30**; transmitter **32**; receiver **34**; and computerized telephone answering system **36**. Transmitter **32** transmits, via transmitting antenna **42**, two local frequencies, namely frequency f_1 and frequency f_2. Receiver **34** is connected to receiver antenna **44** for reception of two local frequencies, namely frequency f_3 and frequency f_4. Computerized telephone answering system **36** is connected to a bank of telephones **48**.

Central computer **30** of central control station **20** comprises a conventional computer equipped with typical components including a CPU **50**; I/O interface **52**; and memory **54**. Although shown only generally in FIG. **1**, it should be understood that memory **54** includes a number of unillustrated memory devices, including (for example) a hard disk drive, RAM, and ROM. FIG. **1** shows that memory **54** has stored therein (among other things) a pager registration file **55** and a pager directory file **56**. Pager files **55** and **56** are typically stored on a hard disk drive of central computer **30**, and upon start-up are loadable into a RAM portion of memory **54**.

Central computer **30** of central control station **20** further includes a decoder **57** (connected between receiver **34** and I/O interface **52** for decoding in-coming communications information from one or more pager units **22**), as well as encoder **58** (connected between I/O interface **52** and transmitter **32** for encoding out-going communications information).

Central control station **20** also includes a clock unit **59** which generates a local clock signal $f_1$clk (which, in turn, is used to modulate frequency f_1).

As illustrated further herein, CPU **50** of central control station **20** prepares communications packets for transmission on frequency f_2. As generally illustrated in FIG. **12**, the communications packets are of a predetermined format, having fields for identification of the central control station, for identification of the addressed pager unit(s) **22**, for an operation code, for (optionally) alphanumeric information, and for other conventional packet-type information such as checksum, error correction, and postamble. The preamble and postamble are specially chosen patterns which can be recognized and distinguished from data for the purpose of determining the beginning and ending of a packet. The alphanumeric information can be in a customary binary 8-bit format. The format of FIG. **12** is illustrative only, as such information as the order of the fields can be varied in other embodiments.

Central control station **20** communicates with a plurality of pager units 22_1, 22_2, . . . 22_N. Only one such pager unit, generically referenced as pager unit **22**, is specifically illustrated and described herein, it being understood that the construction and operation of other pager units may be similar to the one illustration.

As shown in FIG. **2**, pager unit **22** includes a pager receiver antenna **60** which is connected to pager receiver **62**. Pager receiver **62** is, in turn, connected through S/D converter **64** within pager computer **70**. Receiver **62** receives the two local frequencies f_1 and f_2, which frequencies have been modulated to carry in-coming communications information (described in more detail below) to pager computer **70**. On a communications output side, pager computer **70** outputs out-going communications information to pager transmitter **72** via D/S converter **74**. Transmitter **72** broadcasts, on pager antenna **76**, the out-going communications information on the two local frequencies f_3 and f_4.

As also shown in FIG. **2**, pager computer **70** includes pager microprocessor **80** which is connected to each of an arithmetic processor **82**; a memory system **84** (including both ROM and RAM); and I/O interface **86**. I/O interface **86** is connected to a clock unit **87**. I/O interface **86** is also connected to receive in-coming decoded communications information from an 8-bit decoder **88** and to output out-going uncoded communications information to an 8-bit encoder **90**. Decoder **88** is connected to receive in-coming coded communications information from S/D converter **64**; encoder **90** is connected to output out-going coded communications information to D/S converter **74**.

Clock unit **87** is settable by suitable inputs thereto so that clock unit **87** generates a local clock signal $f_1$clk having a frequency corresponding to its input. It should be understood that, in other embodiments, the function of clock unit **87** can be performed at least partially by microprocessor **80** using programmed execution.

I/O interface **86** is also connected to supply an on/off signal on line **92** to pager transmitter **72**, as well as to facilitate input and output with numerous input/output devices. The input/output devices connected to I/O interface **86** include keyboard **93**; beeper **94**; vibrator **95**; and LCD (alphanumeric) display **96**.

Upon manufacture, pager unit **22** is preprogrammed with an identification serial number (e.g., a 7-digit alphanumeric pre-assigned ID number) which is stored in memory **84** (ROM). Pager unit **22** is activated (e.g., at the time of purchase) by inserting a time slot assignment (explained below) both into a predetermined address in memory **84** of pager unit **22** and into pager directory file **56** (stored in memory **54** of central control station **20**).

OPERATION OF FIRST EMBODIMENT

Communication between central control station **20** and pager unit **22** occurs on the four local frequencies, in particular the frequencies f_1, f_2, f_3, and f_4 mentioned above. The first frequency (f_1) carries the local clock-aligning signal from central control station **20** to paging unit **22**. The second frequency (f_2) carries a pager command and alphanumeric data from central control station **20** to paging unit **22**. The third frequency (f_3) carries pager status data and alphanumeric data from, paging unit **22** to central control station **20**. The fourth frequency (f_4) carries a pager request signal from paging unit **22** to central control station **20**. In the illustrated embodiment, the frequencies f_1–f_4 are preferably chosen so that $f_1 \neq f_2 \neq f_3 \neq f_4$.

As explained in more detail below and illustrated in FIG. **13**, in normal non-cell-switching operation, the pager request signal on frequency f_4 is transmitted in a predetermined time slot assigned to paging unit **22**. The predetermined time slot on frequency f_4 is related to the clock-aligning signal (carried by frequency f_1) and assigned whereby the fourth frequency is utilizable by a plurality of other paging units. For example, as shown in FIG. **13**, a first time slot on frequency f_4 is assigned to a pager P1; a second time slot is assigned to page P2, and so on up to time slot n assigned to pager Pn. In the illustrated embodiment, the number of time slots (and accordingly the number of pagers) may be as many as ten thousand or more.

FIG. **3** shows steps executed by CPU **50** of central control station **20** in processing communications to and from one or more paging units. The steps depicted in FIG. **3** are indicative of instructions stored in a ROM portion of memory **54** of central control station **20**.

When central control station **20** is started up (step **100**), an initialization process (step **102**) is conducted. Included in the initialization process is activation of transmitter **32** (so that

transmitter **32** can transmit at the two frequencies f_1 and f_2) and activation of receiver **34** (so that receiver **34** can receive the two frequencies f_3 and f_4). Moreover, frequency f_1 is modulated to carry the local clock-aligning signal generated by local clock **59**. Then, at step **104**, the pager registration file **55** and the pager directory file **56** are loaded from hard disk into a RAM section of memory **54** (step **104**).

After initialization and loading of the files **55** and **56**, CPU **50** repetitively executes an instruction loop **106**. Loop **106** involves checking to determine (at step **108**) whether a telephone message is being received (via answering system **36** from one of the telephones in bank **48**) and checking to determine (at step **110**) whether a pager message is being received (via transmitter **32** from one of the pager units **22**).

As used herein, a message, whether originated from a telephone or from a pager, may require a plurality of packets for transmission from a central station **20** to a pager **22** or vise versa. In the ensuing discussion, transmission and reception of messages subsumes transmission and reception one or more packets. In general, the packetization of messages will be invisible to the user, meaning that a user enters a message without regard to the number of packets which might be required to transmit the message. The message typically ends with a user-entered message termination character or message delimiter character. The transmitting device (either central station **20** or pager **22**), allocates the message to one or more packets having a format similar to that of FIG. **12**, with the last packet in the message bearing the message termination character. Alternatively, the packets may be formatted in a manner to indicate the number of consecutively related packets emanating from a transmitter (e.g., there may be a separate packet field indicating the continuation number of related packets).

Central computer **30** can distinguish between receipt of a telephone message (at step **108**) and a pager message (at step **110**) by virtue of the fact that I/O interface **52** generates different type of interrupts to CPU **50** depending on the type of message received. If it is determined at step **108** that a telephone message is being received, steps **112**, **114**, and **116** of FIG. **3** are executed.

In processing a received telephone message, at step **112** central computer **30** extracts out-going communications information from the predeterminately sequenced telephone-entered data. The telephone-entered data, entered via a touchpad of a calling one of the telephones in bank **48**, includes by convention an identification (e.g., telephone number) of the calling telephone; an identification of the called pager unit (e.g., the 7-digit alphanumeric pre-assigned ID number); and any character data for transmission followed by a termination character. This out-going communications information is received at central computer **30** in standard DTMF format.

At step **114**, using the ID number of the called pager (obtained at step **112**) central computer **30** checks the pager registration file **55** and directory file **56** to determine whether the called pager unit is registered with central control station **20**. Assuming that the called pager is so registered, at step **114** the central computer **30** also obtains from pager directory file **56** the slot assignment for the called pager unit.

At step **116**, central control station **30** transmits communications information to the called pager unit. In this regard, central control station **20** prepares and transmits (on frequency f_2) a communications message which includes, among other things, the ID of the called pager unit and the character data received from the telephone for transmission of the pager unit **22**. After step **116** is executed, processing returns to loop **106**.

If it is determined at step **110** that a pager message is being received, even numbered steps **132–140** of FIG. **3** are executed (prior to returning to loop **106**). As will be seen hereinafter with respect to FIG. **4**, a sending pager unit **22** transmits, in its assigned time slot, a request signal on frequency f_4 when the sending pager unit **22** desires to send a message. As central control station **20** is always monitoring frequency f_4, a request signal carried by frequency f_4 from any pager unit **22** is noted. With reference to the local clock **59**, at step **132** CPU **50** determines in what time slot on frequency f_4 the request signal is detected. Upon detection of the time slot at step **132**, at step **134** CPU **50** consults the pager directory file **56** to determine the identification number of the particular pager unit **22** which originated the request signal.

With the identity of the requesting pager unit **22** now known, at step **136** central control station **20** authorizes the requesting pager unit **22** to transmit its message. In particular, CPU **50** directs preparation of a communications message for transmission on frequency f_2. The particular communications packet prepared at step **136** includes an identification of the requesting pager unit (the addressee of the packet), as well as an operation code ("op" code) which commands/authorizes the requesting pager unit **22** to send its message.

At step **138**, central control station **20** receives a communications message on frequency f_3 sent from the sending (e.g., requesting) pager unit **22**. The communications message prepared and sent by the sending pager unit **22** includes packets of similar format to that shown in FIG. **12**, and includes an identification of a pager to which the message is ultimately addressed as well as its own identification. At step **138**, CPU **50** checks to ensure that the ultimate addressee pager unit is registered in pager files **55** and **56**. At step **140**, CPU **50** makes any necessary reformatting and/or information substitution in the message, and causes the message to be transmitted on frequency f_2. The transmission on frequency f_2 required by step **140** includes the identification of the ultimate addressee (e.g., a pager unit **22**) as well as an operation code indicating that the transmission includes a relayed message from another pager unit.

Steps executed by a pager unit **22** in connection with its transmission mode are depicted in FIG. **4**. Steps executed by a pager unit **22** in connection with its receive mode are depicted in FIG. **5**. The term "mode" as used herein does not connote exclusivity at any particular moment, for it should be remembered that at all times pager unit **22** is receiving transmissions on frequencies f_1 and f_2.

In its transmission mode (see FIG. **4**), after start-up (step **200**) microprocessor **80** of the transmitting pager unit **22** executes a loop **202** wherein user alphanumeric characters (entered via keyboard **93**) are repetitively fetched (at step **204**) until an end of message delimiter is detected (at step **206**). As entered, the characters fetched at step **204** are displayed on LCD display **96**. Entry of the delimiter character at step **206** causes microprocessor **80** to exit loop **202**. By convention, the message must include an addressee ID, which addressee ID is likely the ID of another one of the pager units to which the message entered in step **204** is directed.

After entry of the message awaits entry from keyboard **93** of a transmit command at step **212**. Assuming that the transmit command is entered at step **212**, microprocessor **80** prepares and sends a request signal on frequency f_4. As indicated before, the request signal is transmitted on frequency f_4 in a time slot assigned to the requesting pager unit

22. It should be kept in mind that pager unit **22** is all the while receiving the local clock-aligning signal on frequency f_1, which enables microprocessor **80** to cause transmission of the request signal on frequency f_4 at a time corresponding to the specific time slot allotted to the particular sending pager unit **22**.

In the above regard, in accordance with time division techniques, each pager unit 22_1–22_N (e.g., pagers P_1–P_n in FIG. **13**) is assigned a selected one of N number of time slots on frequency f_4.

After transmission of the request signal at step **214**, pager unit **22** awaits receipt of a transmit command from central control station **20**. Preparation and transmission of the transmit command/authorization from central control station **20** is described with reference to FIG. **3**. Upon receipt of the transmit command/authorization from central control station **20** (step **216**), microprocessor **80** prepares (at step **218**) a communications message with one or more packets having a format much like that of FIG. **12**. The addressee ID and alphanumeric field of packets of the communications message is filled with the message entered in loop **202**. At step **220**, the sending pager unit **22** broadcasts the communications packet on frequency f_3.

If a transmit command is not entered at step **212**, or after transmission of the message at step **220**, microprocessor **80** awaits entry of at least one of several possible special function keys at step **222**. For example, the user may press a function key which requires storage of the message (whether yet transmitted or not) [see step **228**]. Alternatively, the user may press function keys which facilitate editing or erasure of the message (see steps **224** and **226**, respectively). To complete the message and begin work on another message, a special function key for an exit operation (step **230**) must be pressed.

FIG. **5** depicts steps executed by microprocessor **80** of pager unit **22** when in a receive mode. After start-up (step **302**), and as indicated by step **304**, pager unit **22** receives transmissions from central control station **20** on frequency f_2. Once a complete packet is received (determined at step **306**), a check is made (at step **308**) whether the addressee ID in the communications packet (see packet format of FIG. **12**) is the ID of the receiving pager unit **22**. If the determinations of either step **306** or **308** are negative, pager unit **22** awaits either completion of the communications packet (in the case of step **306**) or receipt of another communications packet (in the case of step **308**) by looping back to step **304**.

Assuming that the received communications packet is designated for this particular receiving pager unit **22**, at step **310** microprocessor **80** consults the operation code field of the communications packet (see FIG. **12**) to determine if the operation code indicates that the message includes a command. If the operation code indicates a command, a command processing routine (framed by broken lines **312** in FIG. **5**) is executed.

Assuming for the moment that the operation code does not indicate a command, at step **314** microprocessor **80** of pager unit **22** stores the alphanumeric field portion of the communications packet (which at least partially forms the message) in a RAM portion of memory **84**. Since a message communicated from central processing station **20** may require several communications packets for completion of the message (with subsequent communication packets providing continuations of the message content), microprocessor **80** checks at step **316** to ensure that the entire message has been received. If not, processing continues back at step **304** for reception of a further communications packet.

Upon reception of an entire communications message, at step **318** microprocessor **80** determines whether pager unit **22** is in a beep mode or a vibrate mode. In this regard, there are numerous ways of setting paging unit **22** to the desired mode, either by a specially dedicated switch on paging unit **22** or by data entry using keyboard **93**. If pager unit **22** is in a beep mode, microprocessor **80** outputs a signal which causes I/O interface **86** to issue a further signal to activate beeper **94** (step **320**). Alternatively, if pager unit **22** is in a vibrate mode, microprocessor **80** outputs a signal which causes I/O interface **86** to issue a further signal to activate vibrator **95** (step **322**).

At step **324**, microprocessor **80** directs I/O interface **86** to send the alphanumeric message data to LCD display **96**, so that the received message can be viewed by the user.

After notification to the user (either via beeper **94** and/or vibrator **95**), and display (on LCD **96**) of the received alphanumeric data, microprocessor **80** returns to step to **304** to check whether further communications packets are being received.

The command processing routine (framed by broken lines **312** in FIG. **5**) first determines (step **330**) which particular operation is being commanded. This determination is based on the content of the operation code, which is different for different command types. If the operation code indicates an error shut-down, execution jumps to an error shut-down sub-routine which begins at step **340**. If the operation code indicates a time slot change, execution jumps to a change time slot sub-routine which begins at step **350**. If the operation code requires transmitter shut-down, execution jumps to a transmitter shut-down sub-routine which begins at step **360**. If the operation code requires transmitter re-enablement, execution jumps to a transmitter re-enable sub-routine which begins at step **370**. If the operation code requires clock re-set, execution jumps to a clock re-set sub-routine which begins at step **380**.

In connection with the error shut down sub-routine, at step **342** microprocessor **80** obtains an indication of error type from the communications packet. The error type is stored in memory **84** (step **344**) and then displayed on LCD display **96** (step **346**). Then microprocessor **80** issues a command (at step **348**) to shut down pager unit **22**, which shut-down occurs at step **349**.

In connection with the time slot changing sub-routine, at step **352** microprocessor **80** extracts, from the received communications packet, information indicative of the new time slot assigned to the receiving pager unit **22**. The new time slot is entered (at step **354**) into memory **84** and thereafter utilized (until further change) in connection with transmission of request signals on frequency f_4 (see, for example, step **214** of FIG. **4**). The time slot changing sub-routine may also include other operations, if desired, including (for example) eliminating unused time slots (thereby increasing scanning rate); diagnosing and trouble shooting; and avoiding interruption of service from malfunctioning or ill-functioning equipment.

In connection with the transmitter shut down sub-routine, at step **362** microprocessor **80** directs I/O interface **86** to issue an OFF command to transmitter **72**. In connection with the transmitter re-enable sub-routine, at step **372** microprocessor **80** directs I/O interface **86** to issue an ON command to transmitter **72**.

In connection with the clock re-set sub-routine, at step **382** microprocessor **80** directs that clock **59** of pager unit **22** be set.

After execution of steps **354**, **362**, **372**, or **382**, execution continues back to step **304** for processing of potential further

communications packets. Thus, unless an error shutdown is noted, each entry of the command processing routine (framed by broken lines **312** in FIG. **5**) is followed by a loop back to step **304**.

FIG. **6** is a timing diagram showing the frequencies f_1–f_4 and integration of the steps depicted in FIGS. **3–5**, particularly in the context of a request by a sending pager unit **P1** for sending a message to a sendee pager unit **P2**. As employed in FIG. **6**, "computer" refers to central control station **20**. It should be understood that the sending pager unit **P1** and the sendee pager unit **P2** operate in both the transmission mode as depicted in FIG. **4** and in the receiver mode as depicted in FIG. **5**. In general, FIG. **6** shows transmission of a message from pager unit **P1** (via central control station **20**) to pager unit **P2**; transmission of a confirmation message from pager unit **P2** (via central control station **20**) to pager unit **P1**; and transmission of a message from pager unit **P1** to central control station **20** indicating that pager unit P1 received the confirmation message from pager unit P2.

STRUCTURE OF SECOND EMBODIMENT

FIG. **7** shows a central control station **420** according to a second embodiment of the invention; FIG. **8** shows a paging unit **422** suitable for use with central control station **420**.

FIG. **9** shows a wide area paging system including a plurality of central control stations S1–S8 (each identical to central control station **420**), each preferably geographically centered within a respective cell. Each central control station S1 –S8 broadcasts its own local frequencies, as well as a set of common or switching frequencies C_1–C_4. The common frequencies C_1–C_4 are broadcast at a lower power, so that reception thereof occurs only in a relatively small neighborhood or common frequency reception region (CFRR) [also referred to as a "switching region"] about the central control station. The local frequencies are broadcast at a significantly greater power for reception substantially throughout the cell. For example, in FIG. **9**, central control station **S1** broadcasts its lower power common frequencies C_1–C_4 to $CFRR_1$ and its higher power local frequencies f_1–f_4 to $CELL_1$; central control station **S2** broadcasts its lower power common frequencies C_1–C_4 to $CFRR_2$ and its higher power local frequencies f_5–f_8 to $CELL_2$.

As also shown in FIG. **9**, $CELL_1$ and $CELL_2$ overlap in an overlap region shown in FIG. **9**. Station **S1** utilizes a set of local frequencies f_1–f_4; station **S2** utilizes a different set of local frequencies f_5–f_8. Both stations **S1** and **S2** utilize the same set of common or switching frequencies C_1–C_4. Thus, each central control station utilizes two sets of frequencies, there being four frequencies in each set, resulting in a total of eight frequencies handled per station.

Thus, the second embodiment of the invention is suitable for a system having a plurality of central control stations $420_{x, x=1, 2, \ldots M}$. Each central control station 420_x transmits and receives a set of local frequencies f_{L1}, f_{L2}, f_{L3}, f_{L4} in an associated geographical area or cell, as well as the set of common or switch frequencies C_1, C_2, C_3, C_4. While the values of the local frequencies f_{L1}, f_{L2}, f_{L3}, f_{L4} vary from cell to cell (e.g., differ for differing central control stations 420_x), the values of the common or switch frequencies C_1, C_2, C_3, C_4 are uniform through the system (e.g., for all central control stations 420_x).

Although not shown in FIG. **9**, it should be understood that the pattern of central control stations repeats in like manner in all compass directions in accordance with the prescribed geographical boundaries of the paging system. Moreover, although not specifically illustrated in FIG. **9**, it should also be understood that each central control station **420** has an associated CFRR.

The common or switching frequencies C_1–C_4 have an analogous function to the corresponding local frequencies f_1–f_4, respectively. In this regard, frequency C_1 carries a clock frequency transmitted by central control station(s), although the clock rate on common frequency C_1 preferably varies among central control stations. Frequency C_2 is used to transmit information from central control station(s) to pager unit(s); frequency C_3 is used to transmit information from a pager unit to a central control station; frequency C_4 is used by pager units to issue a request signal. Frequency C_2 carries packets having a format similar to that of FIG. **12**. In analogous manner to frequency f_2, the packets carried by frequency C_2 may have command codes. Among the C_2 command codes are a SYSTEM COMMAND CODE; a LOCAL FREQUENCY DOWNLOAD COMMAND CODE; a SLOT RECOGNITION COMMAND CODE; and a SLOT ASSIGNMENT COMMAND CODE.

As shown in FIG. **7**, central control station **420** resembles central control station **20** of the embodiment of FIG. **1** (similar components being assigned the same reference numerals for simplicity). However, central control station **420** is augmented by inclusion of a further transmitter, known as common frequency transmitter **432**, together with its common frequency transmission antenna **442**, for transmitting the common frequencies C_1 and C_2. In contrast to the high power transmitter **32**, transmitter **432** is a low power transmitter. Further, central control station **420** is augmented by inclusion of a further receiver, known as the common frequency receiver **434**, together with its common frequency receiver antenna **444**, for reception of the common frequencies C_3 and C_4.

Central control station **420** of FIG. **7** includes a clock unit **59'** which generates two clocking signals—a first or local clocking signal $f_L$clk and a second or common clocking signal C_1clk. The local clocking signal $f_L$clk is used to modulate frequency f_1); the common clocking signal is used to modulate the common frequency C_1.

The central computers **30** of the central control stations 420_x are serially connected to one another by an output line **486A** and an input line **486B**. In particular, although not expressly shown as such in FIG. **7**, computer **30** of FIG. **7** (like that of FIG. **1**) includes an I/O interface to which the serial lines **486A** and **486B** are connected. Serial lines **486A** and **486B** are used, for example, to update contents of the pager registration file **55** and the pager directory file **56**.

As shown in FIG. **8**, pager unit **422** resembles pager unit **22** of the embodiment of FIG. **2** (similar components again being assigned the same reference numerals for simplicity).

However, pager unit **422** (in like manner as central control station **420**) is augmented by inclusion of a further transmitter, known as common frequency transmitter **572**, together with its common frequency transmission antenna **576**, for transmitting the common frequencies C_3 and C_4. Further, central control station **420** is augmented by inclusion of a further receiver, known as the common frequency receiver **434**, together with its common frequency receiver antenna **444**, for reception of the common frequencies C_1 and C_2.

The operational frequencies of transmitter **72** and receiver **62** are changeable in accordance with values transmitted on "frequency control" lines from computer **70**. In particular, the frequency control lines are connected to I/O interface **86** in computer **70**. As described in more detail below, when a

pager unit **422** migrates into a new CFRR, signals are applied on the frequency control lines in order to switch pager unit **422** from the local frequencies of an old cell to the local frequencies of a new cell associated with the new CFRR into which pager unit **422** migrates.

Pager **422** includes a clock unit **83'** which is capable of separately generating local clocking signals $f_z$clk and the common clocking signals f_{c1}clk for use by microprocessor **80**. These clocking signals are initiated and their frequencies set by appropriate respective inputs to clock unit **83'**.

FIG. **8** also shows that pager unit **422** has data I/O unit **596** which includes both an alphanumeric graphic display and a pressure sensitive writing pad. The alphanumeric graphic display is a dot matrix device which can display characters and graphics. The writing pad has a 16×48 dot area.

OPERATION OF SECOND EMBODIMENT

As shown in FIG. **9**, a pager unit **P1** is assumed to have been operating in $CELL_1$ and to have previously received the common frequencies C_1–C_4 and local frequencies f_1–f_2 from station **S1**. Now pager unit **P1** travels on a route indicated by broken arrow-headed line ROUTE. In travelling along the ROUTE, pager unit **P1** continues to operate on local frequencies f_1–f_2, even as it travels through the cellular overlap region. However, when page unit **P1** enters a new common frequency reception region (i.e., $CFRR_2$), a switching or hand-off operation occurs. In the switching operation, as explained in more detail below, pager unit **P1** obtains common frequencies C_1–C_4 from central control station **S2** and, as a result, can switch from the local frequencies f_1–f_4 of $CELL_1$ to the local frequencies f_5–f_8 of $CELL_2$. In order to effect the switching or hand-off operation, pager unit **P1** executes a channel switching routine; the central control station **S2** executes a switching enabling routine.

In connection with the channel switching routine and the switching enabling routine, when pager unit **P1** moves into $CFRR_2$. pager unit **P1** will receive the clocking signal on frequency C_1 from station **S2**. At such point, pager unit **P1** will automatically align its clock unit with the clocking signal from station **S2**.

Referring now to the channel switching routine executed by pager **P1** subsequent to start-up (step **500**), at step **506** pager unit **P1** obtains information characterizing the system centered about station **S2**. Such characterizing information is referred to as system identification or system ID information.

At step **508**, microprocessor **80** of pager unit **P1** checks to determine if there is any new system ID information acquired on frequency C_2. That is, microprocessor **80** checks to determine if system ID information is received on frequency C_2 (which can occur only in a CFRR) and, if so, compares the system ID information to the immediately previously-stored system ID information. If the previous and most recently-acquired system IDs are the same, pager unit **P1** realizes that it is still in the jurisdiction of the same station (e.g., station **S1**). If not, pager unit **P1** realizes that it has now wandered into a CFRR of a new station (e.g., station **S2**) and, at step **510**, initiates a request on frequency C_4 for communication with the central control station (e.g., station **S2**) for $CELL_2$.

In the above regard, since pager unit **P1** has not yet been assigned a time slot for $CELL_2$, the request on frequency C_4 is randomly made. However, pager unit **P1** keeps track of the time slot in which it makes its request to the new central control station (e.g., station **S2**).

Thereafter, pager unit **P1** continues to monitor (step **512**) communications packets from station **S2** on frequency C_2, waiting for station **S2** to issue a message which references the time slot at which pager unit **P1** made its request of step **510**. In particular, page unit **P1** awaits a message from station **S2** on frequency C_2 that includes both a SLOT RECOGNITION COMMAND CODE and information stored in the same time slot which pager unit **P1** randomly generated. Since the message including the SLOT RECOGNITION COMMAND CODE includes station **S2** as the sender and mirrors the slot randomly generated by pager unit **P1**, pager unit **P1** recognizes the message as being addressed to pager unit **P1** and considers issuance of such a message by station **S2** (see step **612** of FIG. **11**) to constitute authority for pager unit **P1** to communicate further with station **S2**. In this regard, at step **514** microprocessor **80** of pager unit **P1** determines if there is a match between the time slot of a received message and the time slot at which the random request was made at step **510**.

Assuming a match is eventually found at step **514**, at step **516** pager unit **P1** sends a communications packet on frequency C_3 to station **S2**, with the communications packet including the identification or ID of pager unit **P1**. Using pager registration file **55**, station **S2** verifies that the ID of pager unit **P1** is a valid ID, and thereafter sends (on frequency C_2) to pager unit **P1** a message with the command code LOCAL FREQUENCY DOWNLOAD, which message informs pager unit **P1** of the values of the local frequencies handled by station **S2** (e.g., frequencies f_5–f_8). Thereafter, as also reflected by step **518**, station **S2** sends (on frequency C_2) to pager unit **P1** a message with the command code SLOT ASSIGNMENT COMMAND CODE, which message informs pager unit **P1** of its slot assignment on frequency f_8. Microprocessor **80** thee changes its slot allocation by steps which are similar to those discussed with the afore-mentioned change time slot routine (see steps **350**, **352**, and **354** of FIG. **5**). Step **518** of FIG. **10** reflects reception of the local frequency values and reception of the slot assignment.

After acquisition of all local frequencies and the slot assignment is completed (step **520**), microprocessor **80** implements (at step **522**) a switch to the new local frequencies (e.g., frequencies f_5–f_8). in this regard, microprocessor **80** instructs I/O interface **86** to change transmitter **72** from frequencies f_3, f_4 to frequencies f_7, f_8; and to change receiver **62** from frequencies f_1, f_2 to frequencies f_5, f_6. I/O interface **86** accomplishes the frequency changes by applying appropriate values on the frequency control lines connecting the I/O interface to transmitter **72** and receiver **62**, respectively.

After the switch to new local frequencies at step **522**, microprocessor **80** loops back to step **506**, ultimately to determine when any further switching may be required.

Steps involved in the switching enabling routine executed by a central control station (e.g., station **S2**) are depicted in FIG. **11**. After start-up (step **600**), CPU **50** determines executes a loop **602** which enables CPU **50** to clean up its pager directory file **56** and to check if any new pager units have wandered into the cell which it administers.

In particular, at step **604** CPU determines whether its central control station (e.g., **S2**) has been advised by any other central control station (e.g., **S3**) that a pager unit, formerly under the control of its central control station (e.g., **S2**), has come under the control of the other central control station (e.g, **S3**). Such advisement occurs on the serial links connecting the central control stations 420_x, and particularly input serial link **486**B. If such advisement occurs, the ID for

the wandered-away pager is deleted from the pager directory file **56** for station S2 (as reflected by steps **606** and **608**).

At step **610**, CPU **50** causes messages with a SYSTEM COMMAND CODE to be transmitted on frequency C_2. As indicated before, messages transmitted on frequency C_2 include a packet(s) having a format such as that shown in FIG. **12**. The message with the SYSTEM COMMAND CODE particularly includes the central station ID number in its alphanumeric data field.

At step **612**, central control station **420** checks to determine if a request signal has been transmitted by any pager unit **422** on frequency C_4 (as occurred, for example, in context of the discussion of FIG. **10**, particularly step **510**). Such a request signal would likely be issued from a pager unit **422** which has just wandered into the CFRR controlled by the central control station (e.g., into $CFRR_2$ controlled by station S2). If no such request signal is detected, loop **602** is again repeated.

In the event that a request signal is detected at step **612**, central control station **420** notes specifically the time slot on frequency C_4 at which the request occurred (step **614**). At this point, such time slot is the only way central control station **420** can identify the in-wandering pager unit **422**. Central control station **420** desires for the in-wandering pager unit **422** to transmit its identification (ID), but cannot specifically address the in-wandering pager other than with reference to the detected time slot. Accordingly, at step **616**, central control station **420** prepares and transmits a message on frequency C_2 which has a SLOT RECOGNITION COMMAND CODE. The message including the SLOT RECOGNITION COMMAND CODE includes station S2 as the sender and mirrors the slot randomly generated by pager unit P1 (e.g, the time slot at which the in-wandering pager unit **422** issued its request). This transmission on frequency C_2 constitutes authority for pager unit P1 to transmit its identification.

Step **618** denotes acquisition by central control station **420** of the identification (ID) of the in-wandering pager unit **422**. At step **620**, central control station **420** checks its pager registration file **55** to determine if the pager ID is a valid ID. If not, an error message is generated and transmitted (at step **622**), followed by a command for pager unit P1 to shut down (see step **624**).

Assuming that the identification of pager unit **422** was validated at step **620**, CPU **50** checks (at step **630**) its pager directory file **56** to locate an available time slot for the in-wandering pager unit **422**, and then associates the available time slot with the ID of the in-wandering pager unit **422**. Then, at step **632**, using a message on frequency C_2 with a LOCAL FREQUENCY DOWNLOAD COMMAND CODE, central control station **420** sends the values of its local frequencies (e.g., f_5, f_6, f_7, f_8) to the in-wandering pager unit **422**. The central control station then (at step **634**) assigns to the in-wandering pager unit **422** a new time slot on its local frequencies using a message on frequency C_2 with a SLOT ASSIGNMENT COMMAND CODE. Processing of the change time slot command by the in-wandering pager unit **422** is understood with analogous reference to FIG. **5**, particularly steps **350**, **352**, and **354**.

Upon completion of step **634**, the in wandering pager unit **422** is fully initiated into its new cell (e.g., $CELL_2$), and has left the jurisdiction of its former control station (e.g, CELL, and station S1). Accordingly, at step **636**, CPU **50** requests its I/O interface to issue a command on serial line **486A** which advises (using pager ID) that the in-wandering pager **422** is now under its jurisdiction, so that former jurisdictions (e.g., S1) can delete this pager unit from their pager directory files **56**. Such deletion is understood with reference to steps **604–608** as above-described.

In addition to illustrating geographical location of pager P1, stations S1 and S2, and cells CELL, and $CELL_2$, FIG. **9** shows the relative timing of communications occurring on common frequencies C_1–C_4. FIG. **9** specifically relates the timing of communications transmissions to specific ones of the aforedescribed steps executed by central control station **420** (the switching enabling routine of FIG. **11**) and by pager unit **422** (the channel switching routine of FIG. **10**).

Although the central control stations 420_x use the same common frequencies C_1–C_4, there is no interference or confusion of these signals transmitted from the control stations 420_x. The common frequencies C_1–C_4 are broadcast at a relatively lower power than the local frequencies f_1–f_4, so that reception of the common frequencies C_1–C_4 occurs only in a limited neighborhood (CFRR) about the central control station 420_x. Accordingly, pager units **422** traveling through the system receive common frequencies C_1–C_4 only in the limited and non-overlapping CFRRs.

System operational characteristics, such as cell diameter, CFRR diameter, power level of the local frequencies (e.g., f_1–f_4), and power level of the common frequencies (C_1–C_4) can be field adjusted to suit numerous factors, including particularly the terrain and topography of the geographical region covered by the system. By way of non-limiting example, in one embodiment, the radius of each cell is on the order of about 20 miles; while the radius of each CFRR is on the order of about 10 miles or less. In the same example, the power for transmission of the local frequencies can be in a range of from about 3 watts to 1000 watts; while the power for transmission of the common frequencies C_1–C_4 is preferably less than 2 watts.

Thus, the invention provides a two-way paging system which operates independently from a telephone system for wireless data communication between users. The invention minimizes use of available frequencies allowed by the Federal Communications Commission (FCC), using only four local frequencies f_1–f_4 for any given cell and (for expanded, multi-cellular coverage) only four common or switching frequencies C_1–C_4. In order to minimize the number of frequencies (e.g, channels) utilized, techniques of time division sharing and synchronization are employed. A transmission power differential between the local frequencies and the common frequencies is also employed. These techniques allow data transmission to be kept separate from different pagers and thus eliminates merging of data.

The switching technique of the present invention provides extended geographical coverage and minimizes paging time by increasing the number of frequencies utilized in a cell from four (e.g, the four local frequencies) to eight (the four local frequencies plus the four common frequencies).

In connection with verification of pager ID, it should be understood that a single pager registration file might be stored in a memory file only one of a plurality of central control stations, and that in such case verification would constitute issuing a search command (on the serial links **486**) to locate a pager ID in the one (remote) memory file, with the results of the search being reported back to the inquiring central control station.

The keyboards illustrated herein can, in some embodiments, be multi-language keyboards or writing pads which permit typing of English, Chinese, or Japanese languages, for example. The writing pad is especially useful in countries such as Japan, Thailand, the middle East or

China where English-like alphabets are not used. The writing pad could also be used to sketch and transmit graphics. Moreover, data compression/de-compression techniques can be utilized in connection with data transfer.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various alterations in form and detail may be made therein without departing from the spirit and scope of the invention. For example, it should be understood that repeaters may be employed within cells to facilitate transmission when a pager unit ventures far from a central control station.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of operating a data communication system, the data communication system including a communication controller and a plurality of nodes, the method comprising:

transmitting a first signal from the communication controller to a first node, said first signal specifying a timeslot in which the first node may transmit a capacity request signal to the communication controller;

when the first node has data to transmit, and upon receipt of the first signal, transmitting a capacity request signal from the first node to the communication controller, said capacity request signal including a request for an allocation of bandwidth capacity to transmit data from the first node to the communication controller;

in response to the capacity request signal, transmitting a data grant signal from the communication controller to the node, said data grant signal specifying at least one timeslot for the first node to transmit data to the communication controller; and

in response to receiving the data grant signal, transmitting data from the first node to the communication controller.

2. The method of claim **1** further comprising transmitting data from the first node to the communication controller at a timeslot specified by the data grant signal.

3. The method of claim **1**, wherein the capacity request signal is a time slotted signal carried on a predetermined frequency.

4. The method of claim **1**, wherein said capacity request signal and said data are transmitted to the communication controller via a first channel, and wherein the data grant signal and the first signal are transmitted to the first node via a second channel.

5. The method of claim **4**, wherein the first channel is a time-slotted channel carried on a first frequency, and wherein the second channel is a time-slotted channel carried on a second frequency.

6. The method of claim **1** wherein said system is a pager system, wherein said communication controller comprises a base station, and wherein said first node is a pager device.

7. A method of operating a data communication network, the data communication network including a communication controller and a plurality of nodes, the method comprising:

transmitting a request-enabling signal from the communication controller to a first node;

when the first node has data to transmit, and in response to receiving the request-enabling signal, transmitting a request signal from the first node to the communication controller;

in response to receiving the request signal from the first node, transmitting an authorization signal from the communication controller to the first node; and

in response to receiving the authorization signal, transmitting data from the node to the communication controller.

8. The method of claim **7**, wherein the request-enabling signal is a time slotted signal carried on a predetermined frequency, said request-enabling signal specifying a particular time slot for the first node to transmit said request signal to the communication controller.

9. The method of claim **7**, wherein said request signal and said data are transmitted to the communication controller via a first channel, and wherein the authorization signal and the request-enabling signal are transmitted to the first node via a second channel.

10. The method of claim **9**, wherein the first channel is a time-slotted channel carried on a first frequency, and wherein the second channel is a time-slotted channel carried on a second frequency.

11. The method of claim **7** wherein said network is a pager network, wherein said communication controller comprises a base station, and wherein said first node is a pager device.

12. A data communication system comprising:

a communication controller; and

a plurality of nodes in communication with the communication controller;

the communication controller being configured or designed to transmit a request-enabling signal to a first node;

the first node being configured or designed to transmit a request signal to the communication controller in response to receiving the request-enabling signal, the request signal relating to data to be transmitted to the communication controller;

the communication controller being further configured or designed to transmit an authorization signal to the first node in response to receiving the request signal;

the first node being further configured or designed to transmit data to the communication controller in response to receiving the authorization signal.

13. The system of claim **12**, wherein the request-enabling signal is a time slotted signal carried on a predetermined frequency, said request-enabling signal specifying a particular time slot for the first node to transmit said request signal to the communication controller.

14. The system of claim **12**, wherein said request signal and said data are transmitted to the communication controller via a first channel, and wherein the authorization signal and the request-enabling signal are transmitted to the first node via a second channel.

15. The system of claim **14**, wherein the first channel is a time-slotted channel carried on a first frequency, and wherein the second channel is a time-slotted channel carried on a second frequency.

16. The system of claim **12** wherein said system is a pager system, wherein said communication controller comprises central control station, and wherein said first node is a pager device.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,282,406 B1
DATED : August 28, 2001
INVENTOR(S) : Wong et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

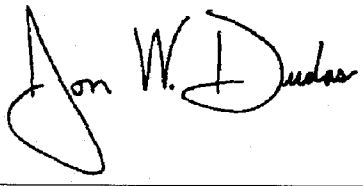
Title page,

Item [63], **Related U.S. Application Data**, please delete the text reading: "Continuation of application No. 08/264,973, filed on Jun. 24, 1994, now Pat. No. 5,542,115." and replace it with it following:

-- Continuation of application No. 09/259,417, filed on Dec. 9, 1997, now Pat. No. 6,108,520, issue August 22, 2000, which is a continuation of 08/608,629 filed Feb. 29, 1996 now Pat. No. 5,729,827, issued March 17, 1998, which is a divisional of 08/264,973 filed June 24, 1994, now Pat. No. 5,542,115, issued July 30, 1996. --

Signed and Sealed this

Thirteenth Day of April, 2004



JON W. DUDAS
Acting Director of the United States Patent and Trademark Office

EXHIBIT B

US007200406B2

(12) **United States Patent**
Wong et al.

(10) **Patent No.: US 7,200,406 B2**
(45) **Date of Patent: *Apr. 3, 2007**

(54) **NETWORK COMMUNICATION SYSTEM USING A SINGLE RESERVATION REQUEST MADE FROM A NODE TO TRANSMIT ITS DATA**

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(73) Assignee: **GPNE Corp.**, Honolulu, HI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/350,616**

(22) Filed: **Feb. 8, 2006**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Continuation of application No. 09/847,005, filed on May 2, 2001, now Pat. No. 7,031,716, which is a continuation of application No. 09/594,662, filed on Jun. 15, 2000, now Pat. No. 6,282,406, which is a continuation of application No. 09/259,417, filed on Dec. 9, 1997, now Pat. No. 6,108,520, which is a continuation of application No. 08/608,629, filed on Feb. 29, 1996, now Pat. No. 5,729,827, which is a division of application No. 08/264,973, filed on Jun. 24, 1994, now Pat. No. 5,542,115.

(51) **Int. Cl.**
H04Q 7/20 (2006.01)
H04Q 7/00 (2006.01)

(52) **U.S. Cl.** **455/450**; 455/509; 455/510; 455/515; 455/516; 455/517; 370/330; 370/336; 370/350; 340/7.2; 340/7.21

(58) **Field of Classification Search** 455/450, 455/509, 510, 515, 516, 517, 436; 370/330, 370/336, 350, 436, 450; 340/7.2, 7.21
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,224,150 A 9/1980 Buriks et al. 210/735

(Continued)

OTHER PUBLICATIONS

Bertsekas, Dimitri, and Gallagher, Robert, Data Networks, pp. 312-317 (Prentice-Hall, Inc., Upper Saddle River, New Jersey 07458, 2nd ed. 1992).

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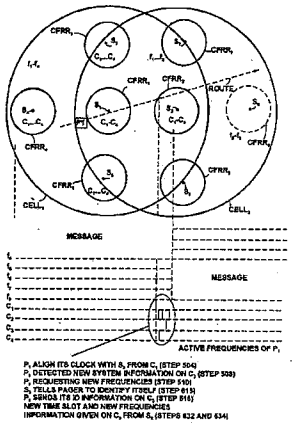
(57) **ABSTRACT**

A network communication system is provided for communication between network nodes, including individual nodes and a central control station node. In the network, signals are transmitted from the central control node to identify specific timeslots in which individual nodes may transmit a request signal to the central control node. When a first individual node then has data to transmit, the first individual node transmits a request signal to the central control node in its identified timeslot requesting allocation of time for transmitting a specified amount of data. In response to the request signal, the central control node transmits a grant signal specifying at least one timeslot allocated to the node for transmit its data to the central control node. The first individual node then in response to the grant signal, transmits its data over the specific timeslots.

96 Claims, 13 Drawing Sheets



U.S. PATENT DOCUMENTS

4,345,491	A	8/1982	Hannon	74/831
4,644,347	A	2/1987	Lucas et al.	340/825.04
4,644,351	A	2/1987	Zabarsky et al.	340/825.44
RE32,365	E	3/1987	Sebestyen	
4,713,808	A	12/1987	Gaskill et al.	370/94
4,747,122	A	5/1988	Bhagat et al.	379/57
4,823,123	A	4/1989	Siwiak	340/825.44
4,845,491	A	7/1989	Fascenda et al.	340/825.44
4,870,402	A	9/1989	DeLuca et al.	340/825.44
4,875,038	A	10/1989	Siwiak et al.	340/825.44
4,882,579	A	11/1989	Siwiak	340/825.44
4,914,649	A	4/1990	Schwendeman et al.	370/50
4,940,963	A	7/1990	Gutman et al.	340/313
RE33,417	E	10/1990	Bhagat et al.	
4,978,944	A	12/1990	Andros et al.	340/825.44
5,012,469	A	4/1991	Sardana	370/95.3
5,043,721	A	8/1991	May	340/825.44
5,086,501	A	2/1992	DeLuca et al.	395/550
5,109,400	A	4/1992	Patsiokas et al.	379/57
5,111,197	A	5/1992	Ichikawa	340/825.44
5,117,449	A	5/1992	Metroka et al.	379/58
5,142,279	A	8/1992	Jasinski et al.	340/825.44
5,153,580	A	10/1992	Pollack	340/825.25
5,170,487	A	12/1992	Peek	455/45
5,197,125	A	3/1993	Engel et al.	395/200
5,206,855	A	4/1993	Schwendeman et al.	370/50
5,224,150	A	6/1993	Neustein	379/57
5,247,700	A	9/1993	Wohl et al.	455/33.1
5,260,986	A	11/1993	Pershan	379/57
5,261,118	A	11/1993	Vanderspool, II et al.	455/51.2
5,276,703	A	1/1994	Budin et al.	375/1
5,278,833	A	1/1994	Crisler et al.	370/95.1
5,285,496	A	2/1994	Frank et al.	380/9
5,297,144	A	3/1994	Gilbert et al.	370/95.2
5,396,496	A	3/1995	Ito et al.	370/50
5,396,537	A	3/1995	Schwendenman	379/57
5,463,675	A	10/1995	Gerszberg	379/60
5,485,463	A	1/1996	Godoroja	370/95.1
5,491,469	A	2/1996	Schwendeman	340/825.04
5,521,925	A	5/1996	Merakos et al.	370/95.3
5,542,115	A	7/1996	Wong et al.	455/53.1
5,680,398	A	10/1997	Robinson	370/458
6,108,520	A	8/2000	Wong et al.	455/31.3
6,282,406	B1	8/2001	Wong et al.	455/31.3

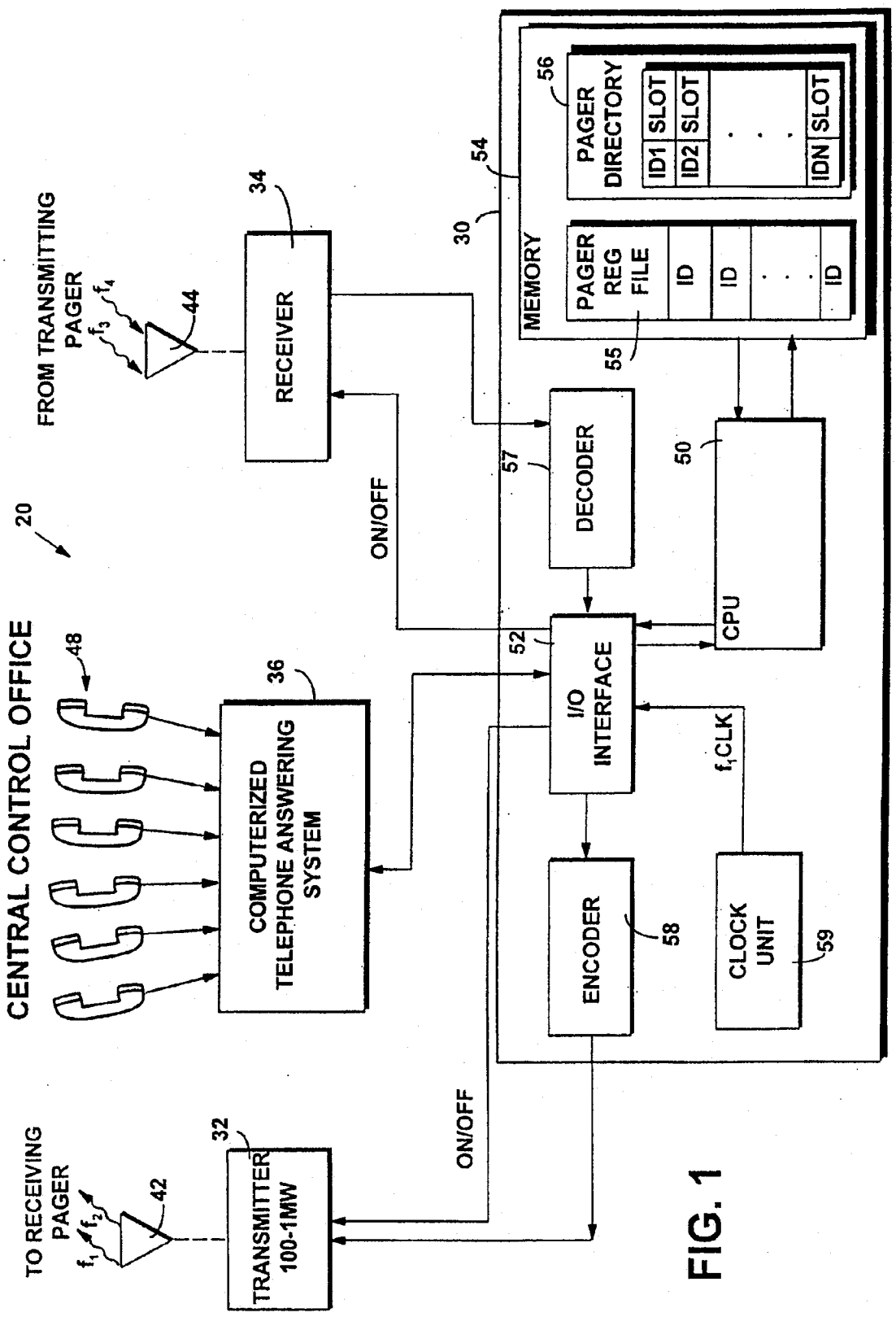

CENTRAL CONTROL OFFICE
20
FROM TRANSMITTING PAGER
f_3 f_4
44
RECEIVER
34
ON/OFF
30
54
MEMORY
PAGER DIRECTORY
56
ID1 SLOT
ID2 SLOT
IDN SLOT
PAGER REG FILE
55
ID
ID
ID
57
DECODER
50
CPU
52
I/O INTERFACE
f_1CLK
48
36
COMPUTERIZED TELEPHONE ANSWERING SYSTEM
ENCODER
58
CLOCK UNIT
59
ON/OFF
TO RECEIVING PAGER
f_1 f_2
42
32
TRANSMITTER 100-1MW

FIG. 1

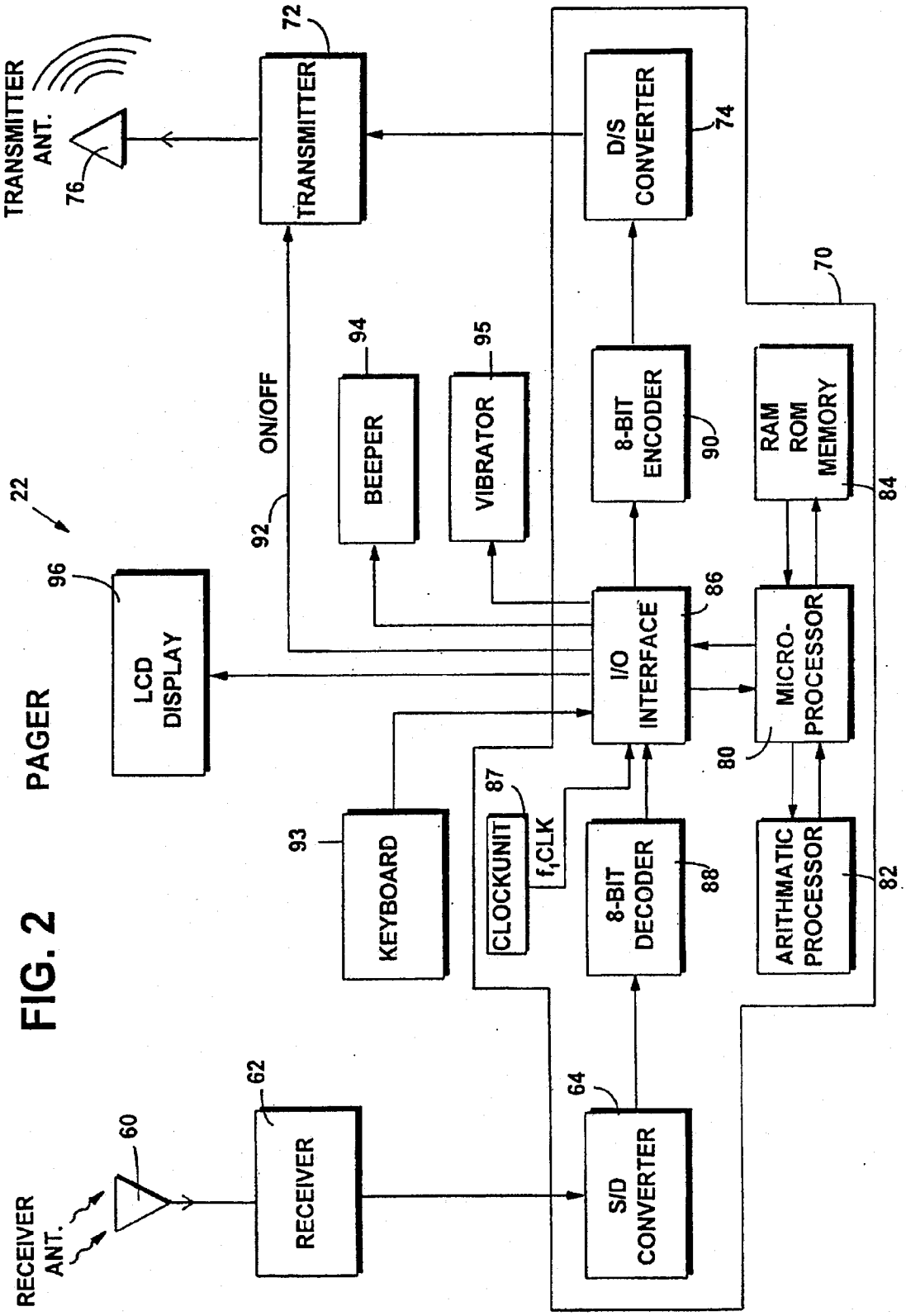
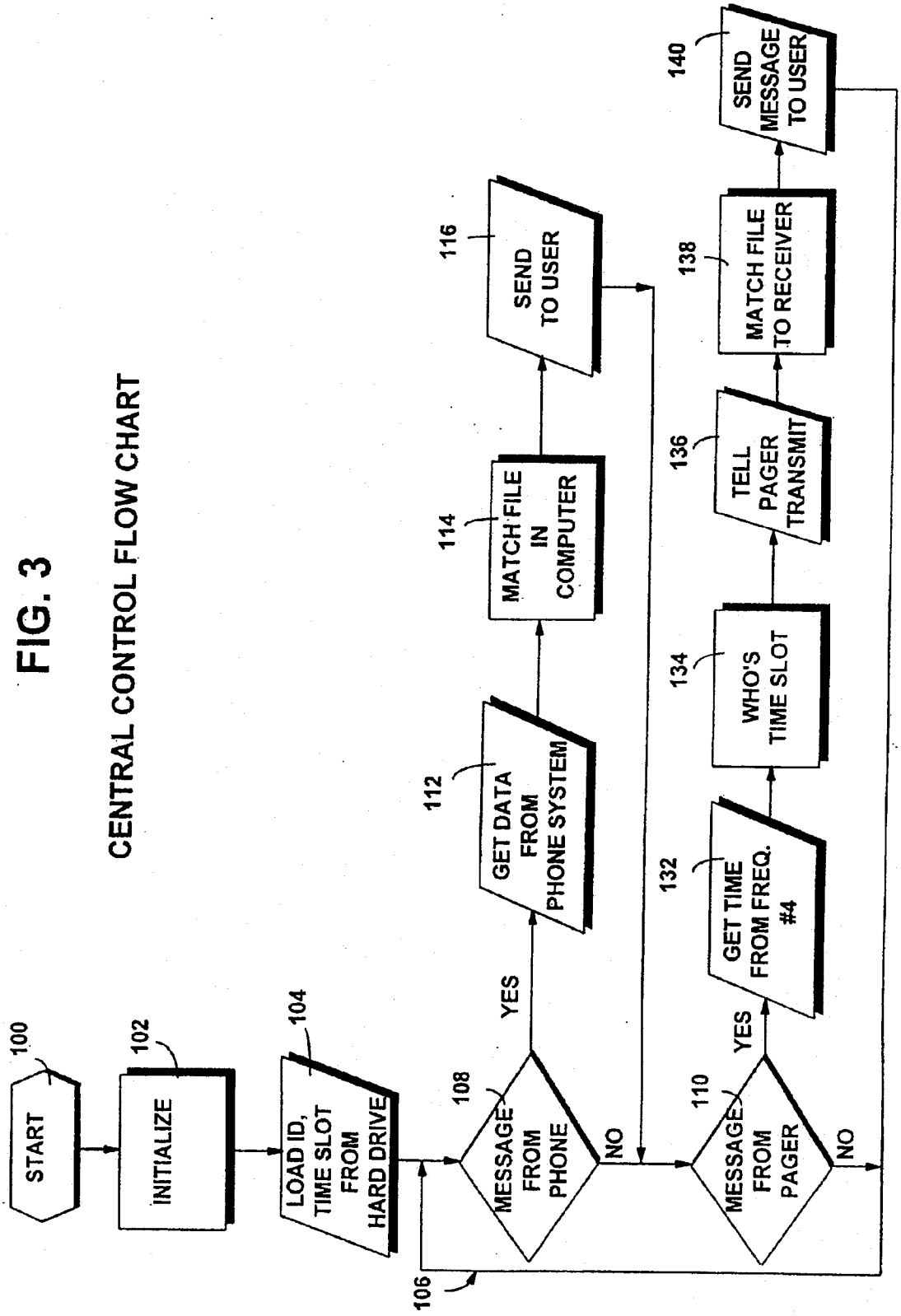

TRANSMITTER ANT.
76
72
TRANSMITTER
D/S CONVERTER
74
70
ON/OFF
92
94
BEEPER
95
VIBRATOR
8-BIT ENCODER
90
RAM ROM MEMORY
84
22
PAGER
96
LCD DISPLAY
I/O INTERFACE
86
MICRO-PROCESSOR
80
87
CLOCKUNIT
f_1CLK
93
KEYBOARD
8-BIT DECODER
88
ARITHMATIC PROCESSOR
82
RECEIVER ANT.
60
62
RECEIVER
64
S/D CONVERTER

FIG. 2

FIG. 3

CENTRAL CONTROL FLOW CHART



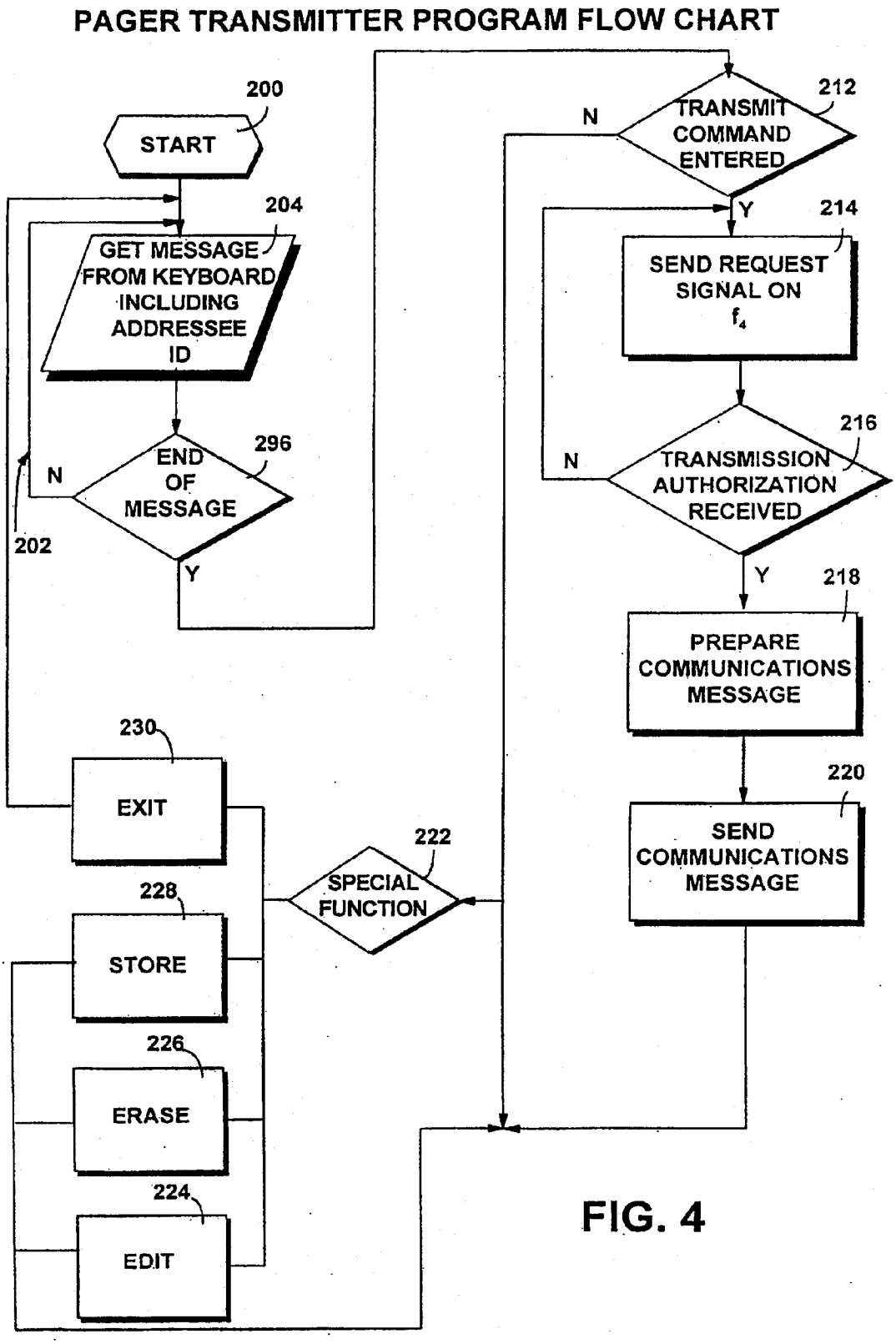

PAGER TRANSMITTER PROGRAM FLOW CHART
200
START
204
GET MESSAGE FROM KEYBOARD INCLUDING ADDRESSEE ID
296
END OF MESSAGE
N
Y
202
212
TRANSMIT COMMAND ENTERED
N
Y
214
SEND REQUEST SIGNAL ON f_4
216
TRANSMISSION AUTHORIZATION RECEIVED
N
Y
218
PREPARE COMMUNICATIONS MESSAGE
220
SEND COMMUNICATIONS MESSAGE
222
SPECIAL FUNCTION
230
EXIT
228
STORE
226
ERASE
224
EDIT

FIG. 4

FIG. 5

PAGER RECEIVER PROGRAM FLOW CHART

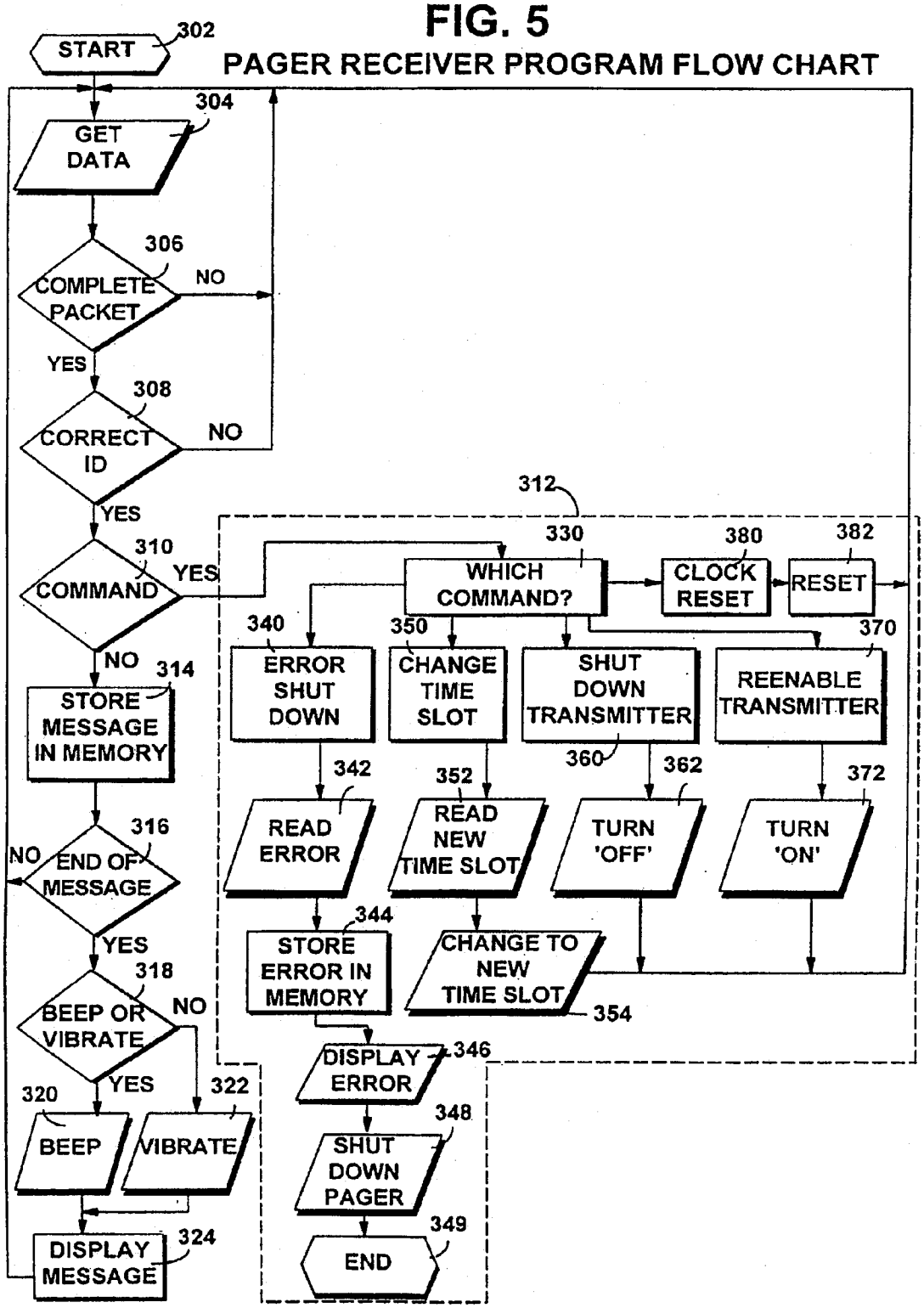


FIG. 6

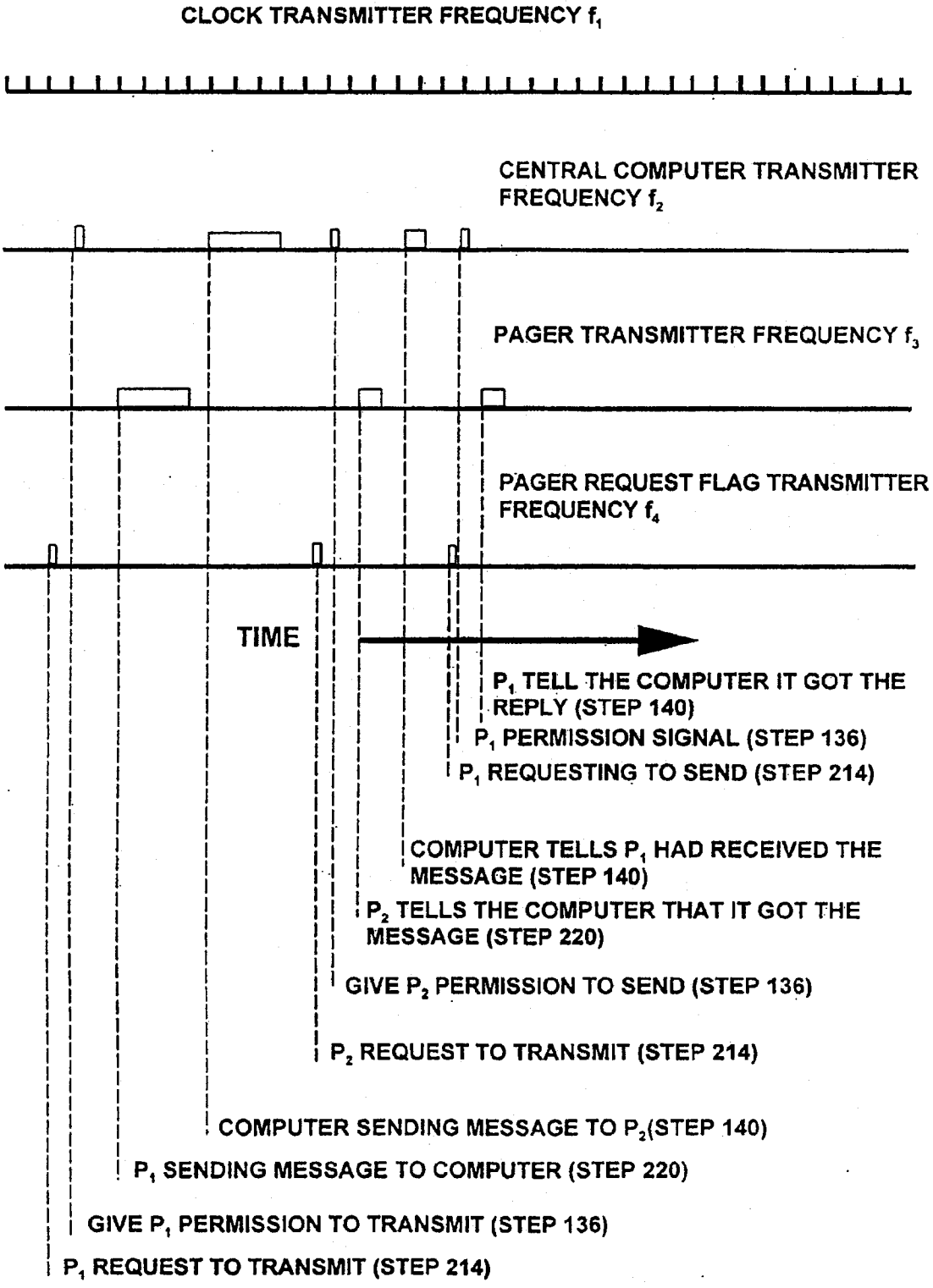

CLOCK TRANSMITTER FREQUENCY f_1
CENTRAL COMPUTER TRANSMITTER FREQUENCY f_2
PAGER TRANSMITTER FREQUENCY f_3
PAGER REQUEST FLAG TRANSMITTER FREQUENCY f_4
TIME
P_1 TELL THE COMPUTER IT GOT THE REPLY (STEP 140)
P_1 PERMISSION SIGNAL (STEP 136)
P_1 REQUESTING TO SEND (STEP 214)
COMPUTER TELLS P_1 HAD RECEIVED THE MESSAGE (STEP 140)
P_2 TELLS THE COMPUTER THAT IT GOT THE MESSAGE (STEP 220)
GIVE P_2 PERMISSION TO SEND (STEP 136)
P_2 REQUEST TO TRANSMIT (STEP 214)
COMPUTER SENDING MESSAGE TO P_2(STEP 140)
P_1 SENDING MESSAGE TO COMPUTER (STEP 220)
GIVE P_1 PERMISSION TO TRANSMIT (STEP 136)
P_1 REQUEST TO TRANSMIT (STEP 214)

FIG. 7

CENTRAL OFFICE LAYOUT

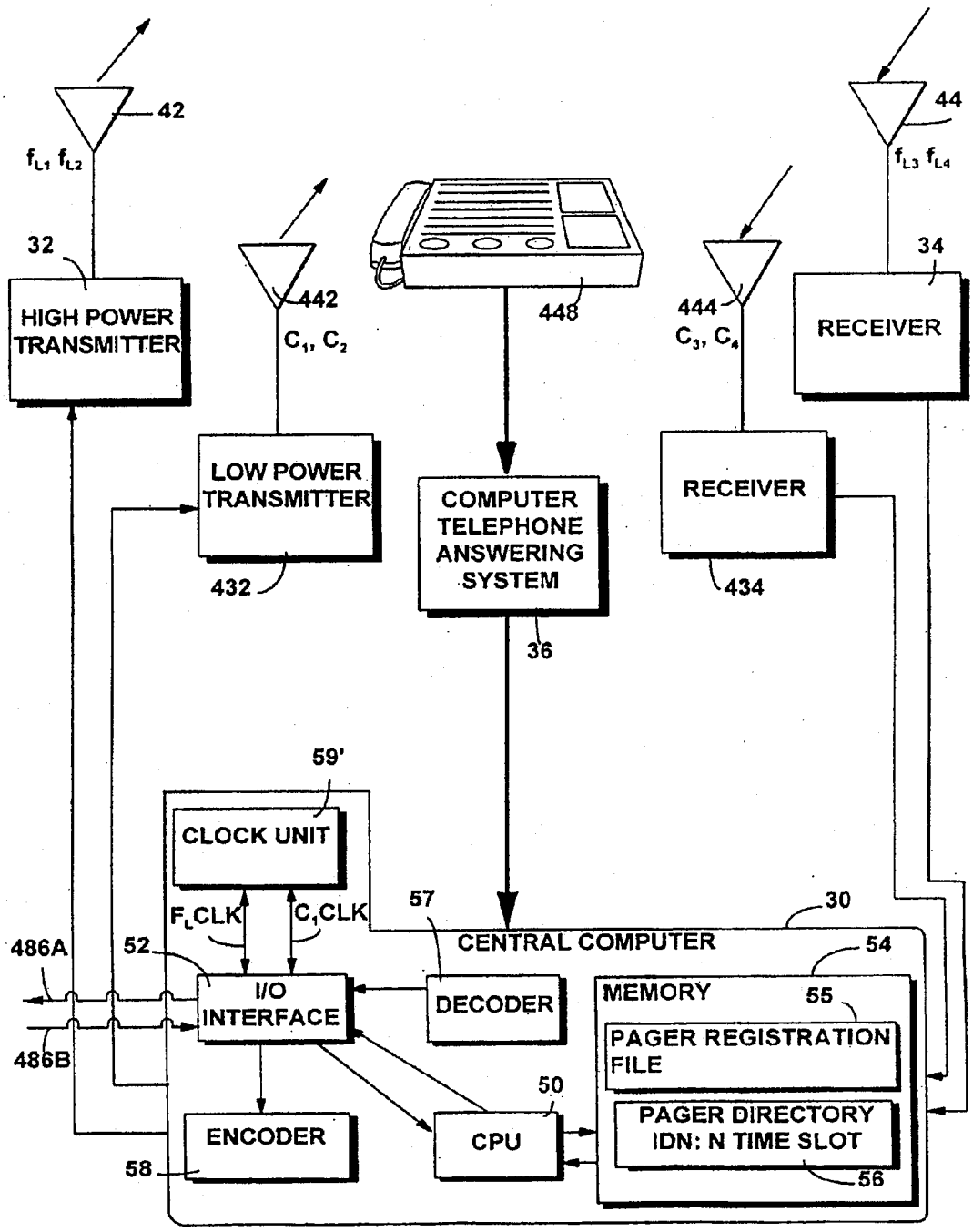


FIG. 8

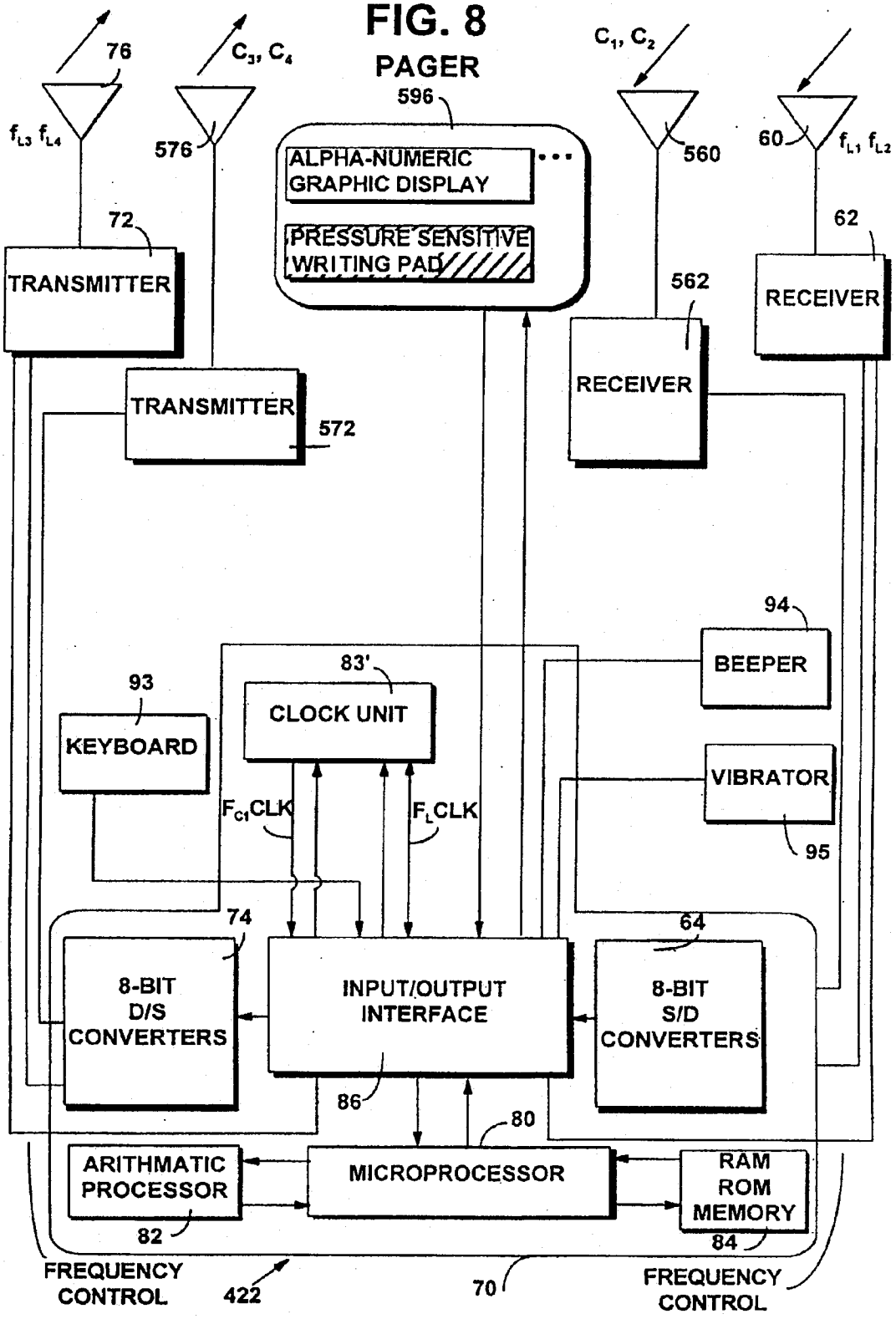
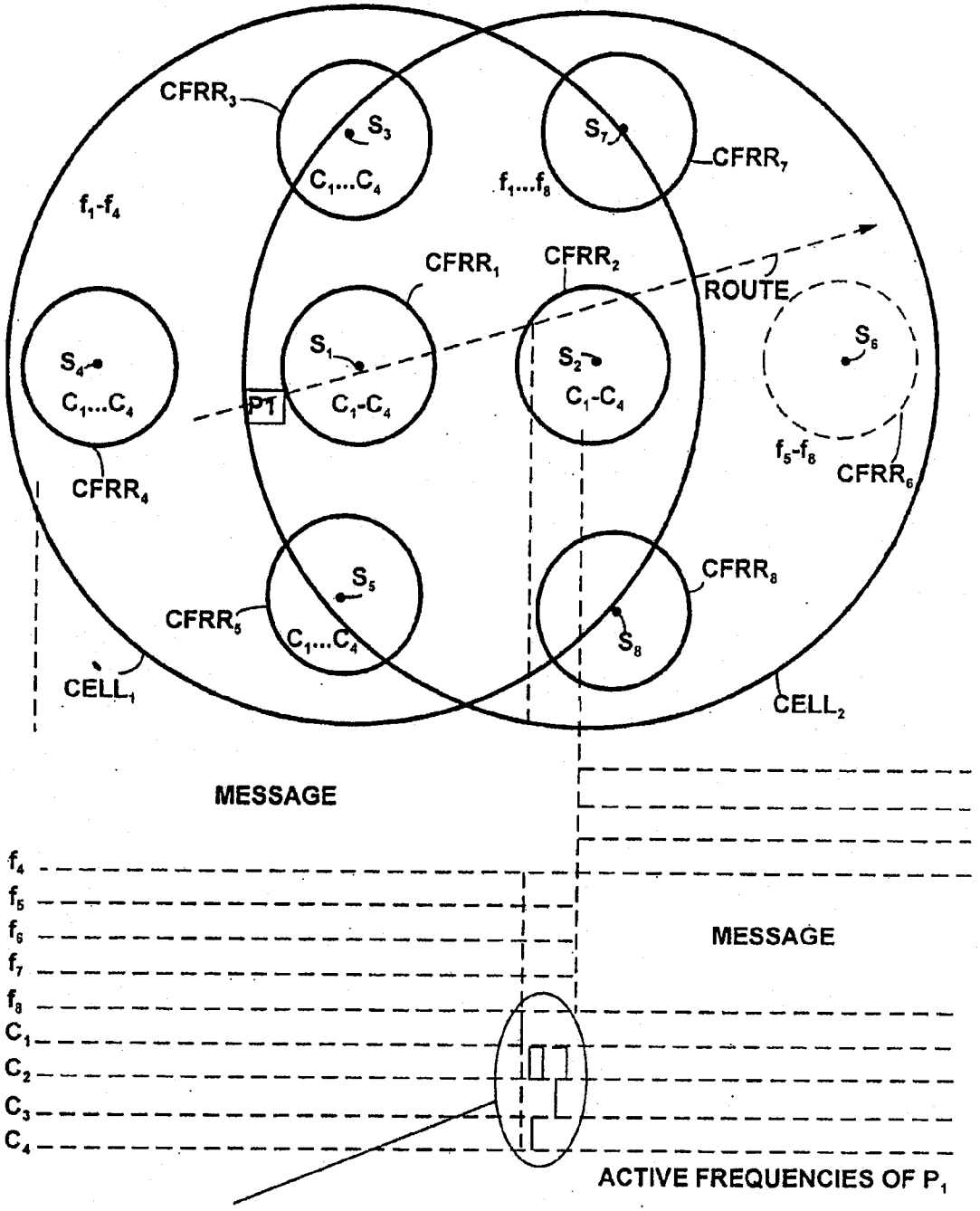

PAGER
596
ALPHA-NUMERIC GRAPHIC DISPLAY
PRESSURE SENSITIVE WRITING PAD
76
f_{L3} f_{L4}
72
TRANSMITTER
C_3, C_4
576
TRANSMITTER
572
C_1, C_2
560
562
RECEIVER
60
f_{L1} f_{L2}
62
RECEIVER
94
BEEPER
83'
CLOCK UNIT
93
KEYBOARD
VIBRATOR
95
F_{C1}CLK
F_LCLK
74
8-BIT D/S CONVERTERS
INPUT/OUTPUT INTERFACE
64
8-BIT S/D CONVERTERS
86
80
ARITHMATIC PROCESSOR
MICROPROCESSOR
RAM ROM MEMORY
82
84
FREQUENCY CONTROL
422
70
FREQUENCY CONTROL

FIG. 9



P1 ALIGN ITS CLOCK WITH S2 FROM C1 (STEP 504)
P1 DETECTED NEW SYSTEM INFORMATION ON C2 (STEP 508)
P1 REQUESTING NEW FREQUENCIES (STEP 510)
S2 TELLS PAGER TO IDENTIFY ITSELF (STEP 616)
P1 SENDS ITS ID INFORMATION ON C3 (STEP 516)
NEW TIME SLOT AND NEW FREQUENCIES
INFORMATION GIVEN ON C2 FROM S2 (STEPS 632 AND 634)

PAGER CHANNEL SWITCHING FLOW CHART

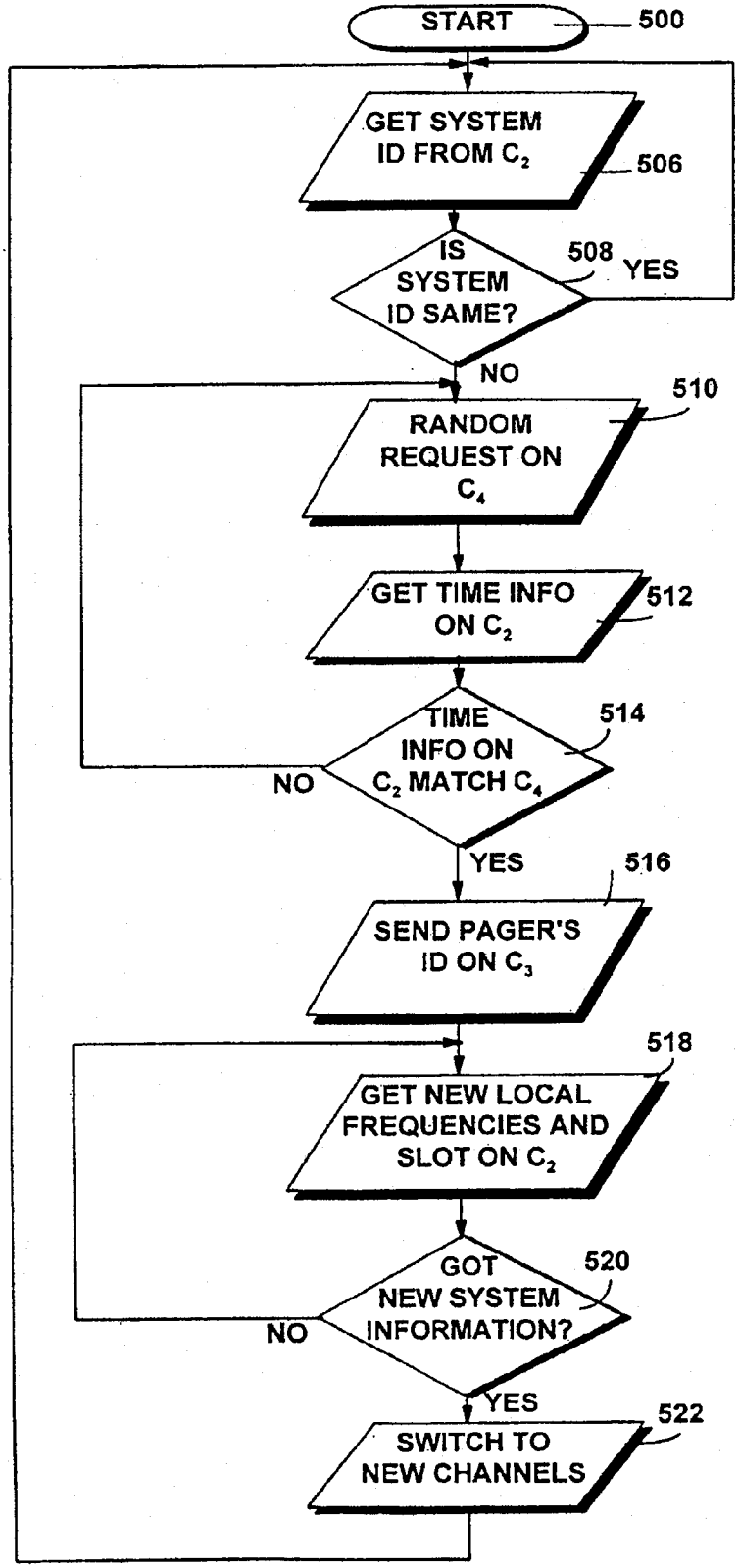
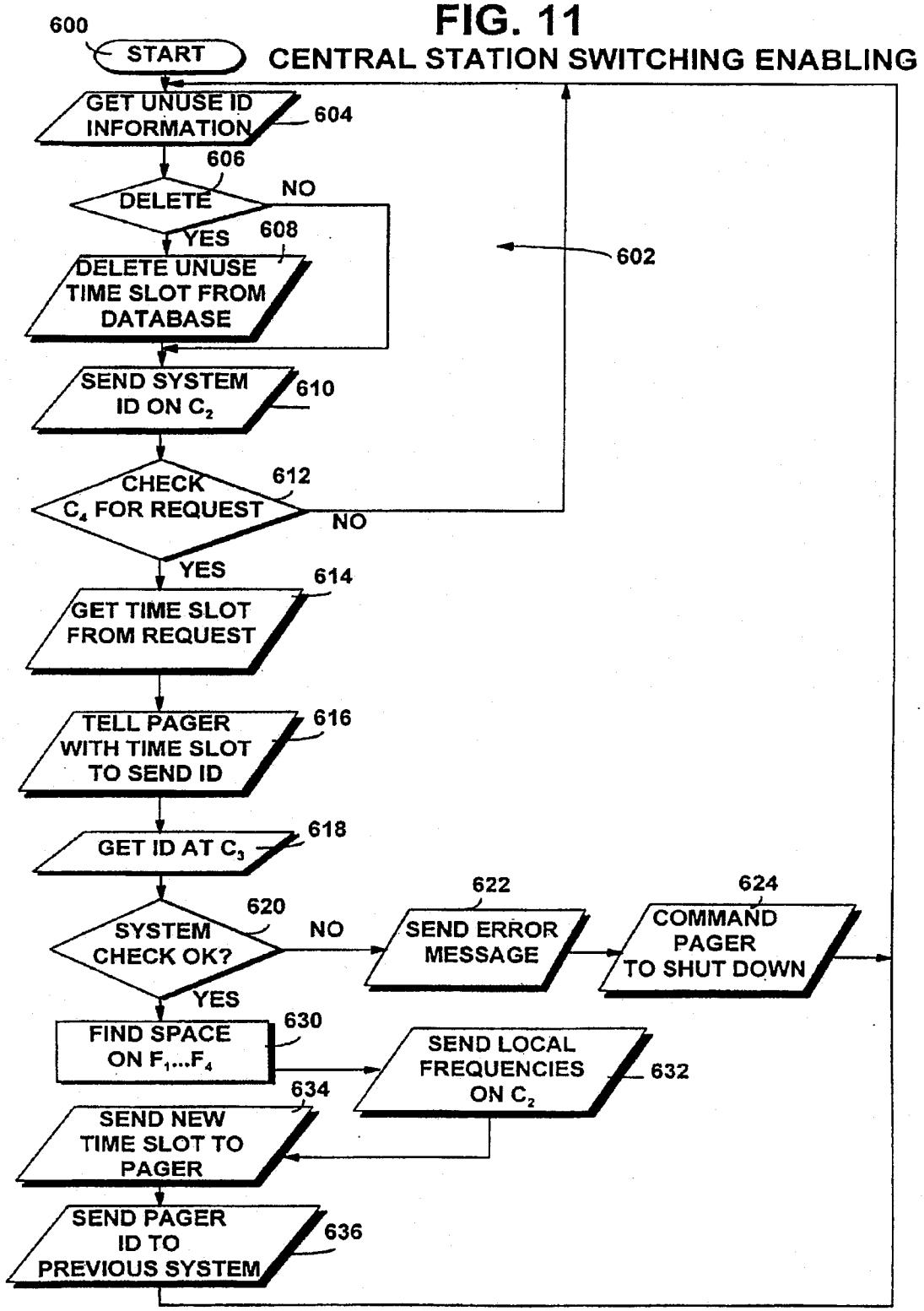


FIG. 10

FIG. 11

CENTRAL STATION SWITCHING ENABLING



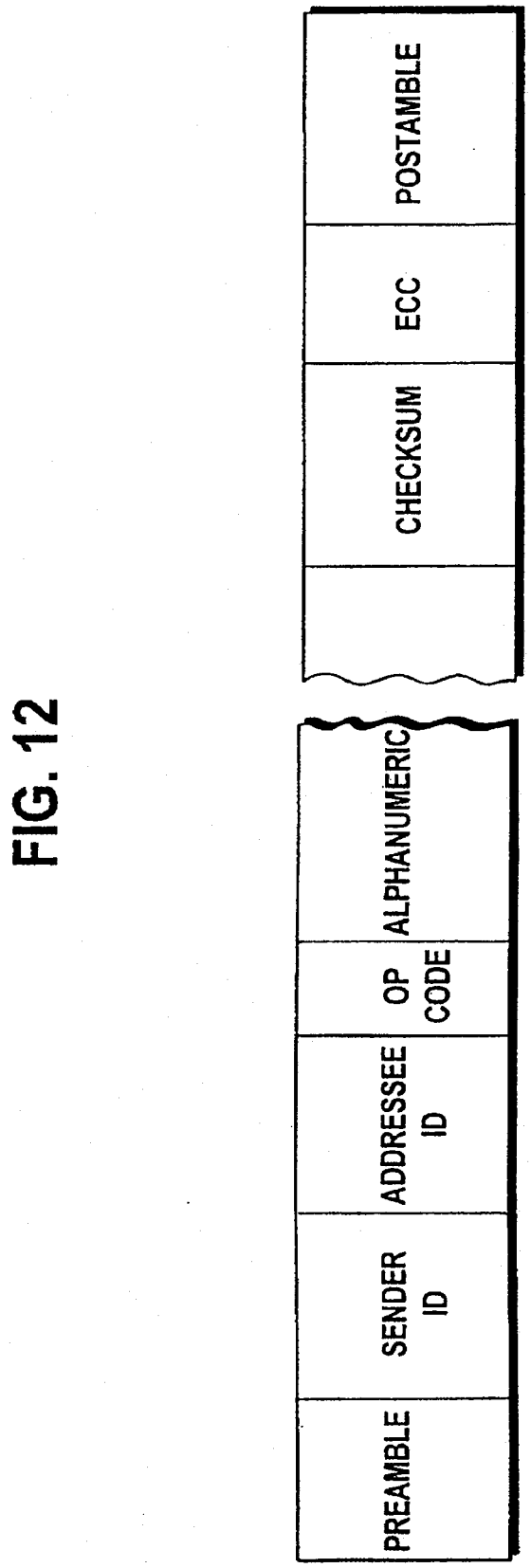
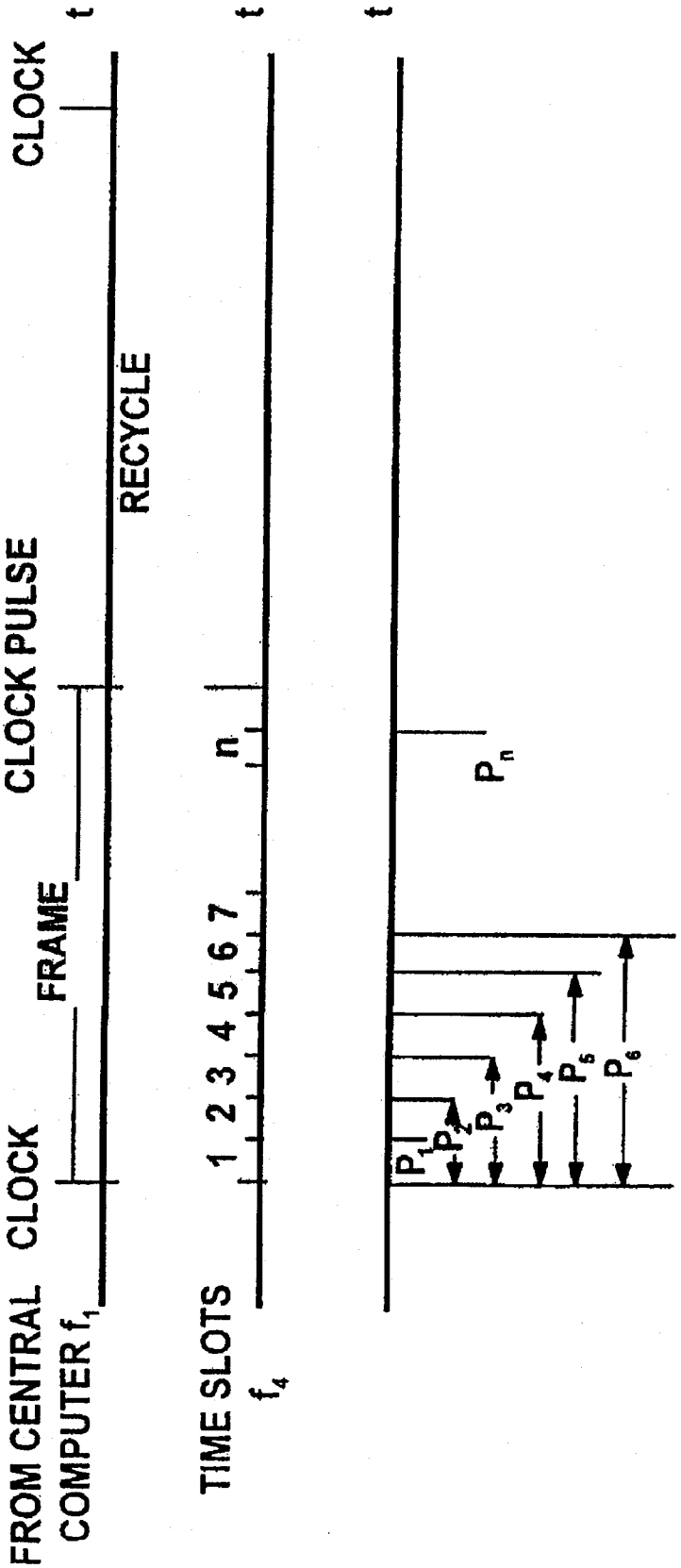

PREAMBLE
SENDER ID
ADDRESSEE ID
OP CODE
ALPHANUMERIC
CHECKSUM
ECC
POSTAMBLE

FIG. 12

FIG. 13


t
t
t
CLOCK
RECYCLE
CLOCK PULSE
FRAME
CLOCK
FROM CENTRAL COMPUTER f_1
n
1 2 3 4 5 6 7
TIME SLOTS
f_4
P_n
P_1
P_2
P_3
P_4
P_5
P_6

NETWORK COMMUNICATION SYSTEM USING A SINGLE RESERVATION REQUEST MADE FROM A NODE TO TRANSMIT ITS DATA

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 09/847,005 filed on May 2, 2001 now U.S. Pat. No. 7,031,716, which is a continuation of application Ser. No. 09/594,662 filed on Jun. 15, 2000 now U.S. Pat. No. 6,282,406, which is a continuation of application Ser. No. 09/259,417 filed on Dec. 9, 1997 now U.S. Pat. No. 6,108,520, which is a continuation of application Ser. No. 08/608,629 filed on Feb. 29, 1996 now U.S. Pat. No. 5,729,827, which is a divisional of Ser. No. 08/264,973, filed Jun. 24, 1994, now U.S. Pat. No. 5,542,115, issued Jul. 30, 1996, entitled "PAGING METHOD AND APPARATUS", naming Wong, et al. as inventors, all of these applications being incorporated by reference herein in their entirety.

BACKGROUND

1. Technical Field

This invention pertains to communications paging, and particularly to two-way paging method and apparatus.

2. Related Art

Over the last several decades, pagers have proven to be important communication devices for contacting remotely situated personnel. Whereas primitive pagers provided primarily only a tonal and/or vibratory output, more modern pagers have enhanced output capabilities such as message-bearing alphanumeric displays.

Paging systems have historically been one-way systems. That is, the user receives a paging message from a central terminal but has no way of responding to that message with the pager. Prior art attempts to provide two-way communication capabilities for a pager have included efforts to connect the pager to a telephone (e.g., to a mobile radio telephone). See, for example, U.S. Pat. No. RE 33,417 to Bhagat et al. (which combines an entire radio pager and radiotelephone linked through an automatic dialer) and U.S. Pat. No. 5,117,449 to Metroka, et. al. (which purports to combine paging and cellular radiotelephone functions in a single unit).

Some pagers have the capability of providing an acknowledgment or response to a paging signal. In some such "ack-back" systems, a user operates a reply input device (e.g., a toggle switch, pushbutton switch, or keyboard) when paged. Typically such ack-back systems involve a complex acknowledgement transmission scheme, involving numerous frequencies or frequency sub-bands. Hand-off of the pager, as the pager travels between differing geographic regions or "cells" served by differing central stations, becomes technically cumbersome when multitudinous frequencies are involved.

SUMMARY

A two-way paging system utilizes four local frequencies for transmissions between pager units and a central control station. A first local frequency carries a local clock; a second local frequency carries communications packets from the central control station to paging units; a third local frequency carries communication packets from the pager units to the central control station; and a fourth local frequency carries a status or request signal from the paging units to the central control station. Transmissions on the fourth local frequency are in accordance with a time divided slot allocation among pager units accessing the central control station.

For a two-way paging system having a plurality of central control stations servicing a corresponding plurality of cells, a total of eight frequencies are utilized within any one cell. Four of the utilized frequencies are the local frequencies, (which may differ from cell to cell), and four of the utilized frequencies are lower power common frequencies or switching frequencies which are used to switch or hand-off a pager unit traveling from one cell to another.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. **1** is a schematic view of a central control station included in a paging system of an embodiment of the invention.

FIG. **2** is a schematic view of a pager unit included in a paging system for use with the central control station of FIG. **1**.

FIG. **3** is a flowchart depicting steps executed by the central control station of FIG. **1**.

FIG. **4** is a flowchart depicting steps executed by the pager unit of FIG. **2** when in a transmit mode.

FIG. **5** is a flowchart depicting steps executed by the pager unit of FIG. **2** when in a receive mode.

FIG. **6** is a timing diagram reflecting communications between the central control station of FIG. **1** and the pager unit of FIG. **2**.

FIG. **7** is a schematic view of a central control station included in a paging system of a second embodiment of the invention.

FIG. **8** is a schematic view of a pager unit included in a paging system for use with the central control station of FIG. **7**.

FIG. **9** is a hybrid schematic view and timing diagram for representing switching operations for the paging system of the second embodiment of the invention.

FIG. **10** is a flowchart depicting steps executed by the pager unit of FIG. **8** in connection with a channel switching operation.

FIG. **11** is a flowchart depicting steps executed by the central control station of FIG. **7** in connection with a channel switching operation.

FIG. **12** is a schematic view of a format of a communications packet utilized with embodiments of the invention.

FIG. **13** is a schematic view illustrating a time divided slot allocation technique according to the invention.

DETAILED DESCRIPTION

FIG. **1** shows a central control station **20** according to a first embodiment of the invention; FIG. **2** shows a paging unit **22** suitable for use with central control station **20**.

As shown in FIG. **1**, central control station **20** includes central computer **30**; transmitter **32**; receiver **34**; and computerized telephone answering system **36**. Transmitter **32**

transmits, via transmitting antenna **42**, two local frequencies, namely frequency f_1 and frequency f_2. Receiver **34** is connected to receiver antenna **44** for reception of two local frequencies, namely frequency f_3 and frequency f_4. Computerized telephone answering system **36** is connected to a bank of telephones **48**.

Central computer **30** of central control station **20** comprises a conventional computer equipped with typical components including a CPU **50**; I/O interface **52**; and memory **54**. Although shown only generally in FIG. **1**, it should be understood that memory **54** includes a number of unillustrated memory devices, including (for example) a hard disk drive, RAM, and ROM. FIG. **1** shows that memory **54** has stored therein (among other things) a pager registration file **55** and a pager directory file **56**. Pager files **55** and **56** are typically stored on a hard disk drive of central computer **30**, and upon start-up are loadable into a RAM portion of memory **54**.

Central computer **30** of central control station **20** further includes a decoder **57** (connected between receiver **34** and I/O interface **52** for decoding in-coming communications information from one or more pager units **22**), as well as encoder **58** (connected between I/O interface **52** and transmitter **32** for encoding out-going communications information).

Central control station **20** also includes a clock unit **59** which generates a local clock signal $f_1$clk (which, in turn, is used to modulate frequency f_1).

As illustrated further herein, CPU **50** of central control station **20** prepares communications packets for transmission on frequency f_2. As generally illustrated in FIG. **12**, the communications packets are of a predetermined format, having fields for identification of the central control station, for identification of the addressed pager unit(s) **22**, for an operation code, for (optionally) alphanumeric information, and for other conventional packet-type information such as checksum, error correction, and postamble. The preamble and postamble are specially chosen patterns which can be recognized and distinguished from data for the purpose of determining the beginning and ending of a packet. The alphanumeric information can be in a customary binary 8-bit format. The format of FIG. **12** is illustrative only, as such information as the order of the fields can be varied in other embodiments.

Central control station **20** communicates with a plurality of pager units 22_1, 22_2, . . . 22_N. Only one such pager unit, generically referenced as pager unit **22**, is specifically illustrated and described herein, it being understood that the construction and operation of other pager units may be similar to the one illustration.

As shown in FIG. **2**, pager unit **22** includes a pager receiver antenna **60** which is connected to pager receiver **62**. Pager receiver **62** is, in turn, connected through S/D converter **64** within pager computer **70**. Receiver **62** receives the two local frequencies f_1, and f_2, which frequencies have been modulated to carry in-coming communications information (described in more detail below) to pager computer **70**. On a communications output side, pager computer **70** outputs out-going communications information to pager transmitter **72** via D/S converter **74**. Transmitter **72** broadcasts, on pager antenna **76**, the out-going communications information on the two local frequencies f_3 and f_4.

As also shown in FIG. **2**, pager computer **70** includes pager microprocessor **80** which is connected to each of an arithmetic processor; a memory system **84** (including both ROM and RAM); and I/O interface **86**. I/O interface **86** is connected to a clock unit **87**. I/O interface **86** is also connected to receive in-coming decoded communications information from an 8-bit decoder **88** and to output out-going uncoded communications information to an 8-bit encoder **90**. Decoder **88** is connected to receive in-coming coded communications information from S/D converter **64**; encoder **90** is connected to output out-going coded communications information to D/S converter **74**.

Clock unit **87** is settable by suitable inputs thereto so that clock unit **87** generates a local clock signal $f_1$clk having a frequency corresponding to its input. It should be understood that, in other embodiments, the function of clock unit **87** can be performed at least partially by microprocessor **80** using programmed execution.

I/O interface **86** is also connected to supply an on/off signal on line **92** to pager transmitter **72**, as well as to facilitate input and output with numerous input/output devices. The input/output devices connected to I/O interface **86** include keyboard **93**; beeper **94**; vibrator **95**; and LCD (alphanumeric) display **96**.

Upon manufacture, pager unit **22** is preprogrammed with an identification serial number (e.g., a 7-digit alphanumeric pre-assigned ID number) which is stored in memory **84** (ROM). Pager unit **22** is activated (e.g., at the time of purchase) by inserting a time slot assignment (explained below) both into a predetermined address in memory **84** of pager unit **22** and into pager directory file **56** (stored in memory **54** of central control station **20**).

Operation of First Embodiment

Communication between central control station **20** and pager unit **22** occurs on the four local frequencies, in particular the frequencies f_1, f_2, f_3, and f_4 mentioned above. The first frequency (f_1) carries the local clock-aligning signal from central control station **20** to paging unit **22**. The second frequency (f_2) carries a pager command and alphanumeric data from central control station **20** to paging unit **22**. The third frequency (f_3) carries pager status data and alphanumeric data from. paging unit **22** to central control station **20**. The fourth frequency (f_4) carries a pager request signal from paging unit **22** to central control station **20**. In the illustrated embodiment, the frequencies f_1–f_4 are preferably chosen so that $f_1 \neq f_2 \neq f_3 \neq f_4$.

As explained in more detail below and illustrated in FIG. **13**, in normal non-cell-switching operation, the pager request signal on frequency f_4 is transmitted in a predetermined time slot assigned to paging unit **22**. The predetermined time slot on frequency f_4 is related to the clock-aligning signal (carried by frequency f_1) and assigned whereby the fourth frequency is utilizable by a plurality of other paging units. For example, as shown in FIG. **13**, a first time slot on frequency f_4 is assigned to a pager P1; a second time slot is assigned to pager P2, and so on up to time slot n assigned to pager Pn. In the illustrated embodiment, the number of time slots (and accordingly the number of pagers) may be as many as ten thousand or more.

FIG. **3** shows steps executed by CPU **50** of central control station **20** in processing communications to and from one or more paging units. The steps depicted in FIG. **3** are indicative of instructions stored in a ROM portion of memory **54** of central control station **20**.

When central control station **20** is started up (step **100**), an initialization process (step **102**) is conducted. Included in the initialization process is activation of transmitter **32** (so that transmitter **32** can transmit at the two frequencies f_1 and f_2) and activation of receiver **34** (so that receiver **34** can receive the two frequencies f_3 and f_4). Moreover, frequency f_1 is

modulated to carry the local clock-aligning signal generated by local clock **59**. Then, at step **104**, the pager registration file **55** and the pager directory file **56** are loaded from hard disk into a RAM section of memory **54** (step **104**).

After initialization and loading of the files **55** and **56**, CPU **50** repetitively executes an instruction loop **106**. Loop **106** involves checking to determine (at step **108**) whether a telephone message is being received (via answering system **36** from one of the telephones in bank **48**) and checking to determine (at step **110**) whether a pager message is being received (via transmitter **32** from one of the pager units **22**).

As used herein, a message, whether originated from a telephone or from a pager, may require a plurality of packets for transmission from a central station **20** to a pager **22** or vise versa. In the ensuing discussion, transmission and reception of messages subsumes transmission and reception one or more packets. In general, the packetization of messages will be invisible to the user, meaning that a user enters a message without regard to the number of packets which might be required to transmit the message. The message typically ends with a user-entered message termination character or message delimiter character. The transmitting device (either central station **20** or pager **22**), allocates the message to one or more packets having a format similar to that of FIG. **12**, with the last packet in the message bearing the message termination character. Alternatively, the packets may be formatted in a manner to indicate the number of consecutively related packets emanating from a transmitter (e.g., there may be a separate packet field indicating the continuation number of related packets).

Central computer **30** can distinguish between receipt of a telephone message (at step **108**) and a pager message (at step **110**) by virtue of the fact that I/O interface **52** generates different type of interrupts to CPU **50** depending on the type of message received. If it is determined at step **108** that a telephone message is being received, steps **112**, **114**, and **116** of FIG. **3** are executed.

In processing a received telephone message, at step **112** central computer **30** extracts out-going communications information from the predeterminately sequenced telephone-entered data. The telephone-entered data, entered via a touchpad of a calling one of the telephones in bank **48**, includes by convention an identification (e.g., telephone number) of the calling telephone; an identification of the called pager unit (e.g., the 7-digit alphanumeric pre-assigned ID number); and any character data for transmission followed by a termination character. This out-going communications information is received at central computer **30** in standard DTMF format.

At step **114**, using the ID number of the called pager (obtained at step **112**) central computer **30** checks the pager registration file **55** and directory file **56** to determine whether the called pager unit is registered with central control station **20**. Assuming that the called pager is so registered, at step **114** the central computer **30** also obtains from pager directory file **56** the slot assignment for the called pager unit.

At step **116**, central control station **30** transmits communications information to the called pager unit. In this regard, central control station **20** prepares and transmits (on frequency f_2) a communications message which includes, among other things, the ID of the called pager unit and the character data received from the telephone for transmission of the pager unit **22**. After step **116** is executed, processing returns to loop **106**.

If it is determined at step **110** that a pager message is being received, even numbered steps **132–140** of FIG. **3** are executed (prior to returning to loop **106**). As will be seen hereinafter with respect to FIG. **4**, a sending pager unit **22** transmits, in its assigned time slot, a request signal on frequency f_4 when the sending pager unit **22** desires to send a message. As central control station **20** is always monitoring frequency f_4, a request signal carried by frequency f_4 from any pager unit **22** is noted. With reference to the local clock **59**, at step **132** CPU **50** determines in what time slot on frequency f_4 the request signal is detected. Upon detection of the time slot at step **132**, at step **134** CPU **50** consults the pager directory file **56** to determine the identification number of the particular pager unit **22** which originated the request signal.

With the identity of the requesting pager unit **22** now known, at step **136** central control station **20** authorizes the requesting pager unit **22** to transmit its message. In particular, CPU **50** directs preparation of a communications message for transmission on frequency f_2. The particular communications packet prepared at step **136** includes an identification of the requesting pager unit (the addressee of the packet), as well as an operation code ("op" code) which commands/authorizes the requesting pager unit **22** to send its message.

At step **138**, central control station **20** receives a communications message on frequency f_3 sent from the sending (e.g., requesting) pager unit **22**. The communications message prepared and sent by the sending pager unit **22** includes packets of similar format to that shown in FIG. **12**, and includes an identification of a pager to which the message is ultimately addressed as well as its own identification. At step **138**, CPU **50** checks to ensure that the ultimate addressee pager unit is registered in pager files **55** and **56**. At step **140**, CPU **50** makes any necessary reformatting and/or information substitution in the message, and causes the message to be transmitted on frequency f_2. The transmission on frequency f_2 required by step **140** includes the identification of the ultimate addressee (e.g., a pager unit **22**) as well as an operation code indicating that the transmission includes a relayed message from another pager unit.

Steps executed by a pager unit **22** in connection with its transmission mode are depicted in FIG. **4**. Steps executed by a pager unit **22** in connection with its receive mode are depicted in FIG. **5**. The term "mode" as used herein does not connote exclusivity at any particular moment, for it should be remembered that at all times pager unit **22** is receiving transmissions on frequencies f_1 and f_2.

In its transmission mode (see FIG. **4**), after start-up (step **200**) microprocessor **80** of the transmitting pager unit **22** executes a loop **202** wherein user alphanumeric characters (entered via keyboard **93**) are repetitively fetched (at step **204**) until an end of message delimiter is detected (at step **206**). As entered, the characters fetched at step **204** are displayed on LCD display **96**. Entry of the delimiter character at step **206** causes microprocessor **80** to exit loop **202**. By convention, the message must include an addressee ID, which addressee ID is likely the ID of another one of the pager units to which the message entered in step **204** is directed.

After entry of the message awaits entry from keyboard **93** of a transmit command at step **212**. Assuming that the transmit command is entered at step **212**, microprocessor **80** prepares and sends a request signal on frequency f_4. As indicated before, the request signal is transmitted on frequency f_4 in a time slot assigned to the requesting pager unit **22**. It should be kept in mind that pager unit **22** is all the while receiving the local clock-aligning signal on frequency f_1, which enables microprocessor **80** to cause transmission

of the request signal on frequency f_4 at a time corresponding to the specific time slot allotted to the particular sending pager unit **22**.

In the above regard, in accordance with time division techniques, each pager unit 22_1–22_N (e.g., pagers P_1–P_N in FIG. **13**) is assigned a selected one of N number of time slots on frequency f_4.

After transmission of the request signal at step **214**, pager unit **22** awaits receipt of a transmit command from central control station **20**. Preparation and transmission of the transmit command/authorization from central control station **20** is described with reference to FIG. **3**. Upon receipt of the transmit command/authorization from central control station **20** (step **216**), microprocessor **80** prepares (at step **218**) a communications message with one or more packets having a format much like that of FIG. **12**. The addressee ID and alphanumeric field of packets of the communications message is filled with the message entered in loop **202**. At step **220**, the sending pager unit **22** broadcasts the communications packet on frequency f_3.

If a transmit command is not entered at step **212**, or after transmission of the message at step **220**, microprocessor **80** awaits entry of at least one of several possible special function keys at step **222**. For example, the user may press a function key which requires storage of the message (whether yet transmitted or not) [see step **228**]. Alternatively, the user may press function keys which facilitate editing or erasure of the message (see steps **224** and **226**, respectively). To complete the message and begin work on another message, a special function key for an exit operation (step **230**) must be pressed.

FIG. **5** depicts steps executed by microprocessor **80** of pager unit **22** when in a receive mode. After start-up (step **302**), and as indicated by step **304**, pager unit **22** receives transmissions from central control station **20** on frequency f_2. Once a complete packet is received (determined at step **306**), a check is made (at step **308**) whether the addressee ID in the communications packet (see packet format of FIG. **12**) is the ID of the receiving pager unit **22**. If the determinations of either step **306** or **308** are negative, pager unit **22** awaits either completion of the communications packet (in the case of step **306**) or receipt of another communications packet (in the case of step **308**) by looping back to step **304**.

Assuming that the received communications packet is designated for this particular receiving pager unit **22**, at step **310** microprocessor **80** consults the operation code field of the communications packet (see FIG. **12**) to determine if the operation code indicates that the message includes a command. If the operation code indicates a command, a command processing routine (framed by broken lines **312** in FIG. **5**) is executed.

Assuming for the moment that the operation code does not indicate a command, at step **314** microprocessor **80** of pager unit **22** stores the alphanumeric field portion of the communications packet (which at least partially forms the message) in a RAM portion of memory **84**. Since a message communicated from central processing station **20** may require several communications packets for completion of the message (with subsequent communication packets providing continuations of the message content), microprocessor **80** checks at step **316** to ensure that the entire message has been received. If not, processing continues back at step **304** for reception of a further communications packet.

Upon reception of an entire communications message, at step **318** microprocessor **80** determines whether pager unit **22** is in a beep mode or a vibrate mode. In this regard, there are numerous ways of setting paging unit **22** to the desired mode, either by a specially dedicated switch on paging unit **22** or by data entry using keyboard **93**. If pager unit **22** is in a beep mode, microprocessor **80** outputs a signal which causes I/O interface **86** to issue a further signal to activate beeper **94** (step **320**). Alternatively, if pager unit **22** is in a vibrate mode, microprocessor **80** outputs a signal which causes I/O interface **86** to issue a further signal to activate vibrator **95** (step **322**).

At step **324**, microprocessor **80** directs I/O interface **86** to send the alphanumeric message data to LCD display **96**, so that the received message can be viewed by the user.

After notification to the user (either via beeper **94** and/or vibrator **95**), and display (on LCD **96**) of the received alphanumeric data, microprocessor **80** returns to step **304** to check whether further communications packets are being received.

The command processing routine (framed by broken lines **312** in FIG. **5**) first determines (step **330**) which particular operation is being commanded. This determination is based on the content of the operation code, which is different for different command types. If the operation code indicates an error shut-down, execution jumps to an error shut-down sub-routine which begins at step **340**. If the operation code indicates a time slot change, execution jumps to a change time slot sub-routine which begins at step **350**. If the operation code requires transmitter shut-down, execution jumps to a transmitter shut-down sub-routine which begins at step **360**. If the operation code requires transmitter re-enablement, execution jumps to a transmitter reenable sub-routine which begins at step **370**. If the operation code requires clock re-set, execution jumps to a clock re-set sub routine which begins at step **380**.

In connection with the error shut down sub-routine, at step **342** microprocessor **80** obtains an indication of error type from the communications packet. The error type is stored in memory **84** (step **344**) and then displayed on LCD display **96** (step **346**). Then microprocessor **80** issues a command (at step **348**) to shut down pager unit **22**, which shut-down occurs at step **349**.

In connection with the time slot changing sub-routine, at step **352** microprocessor **80** extracts, from the received communications packet, information indicative of the new time slot assigned to the receiving pager unit **22**. The new time slot is entered (at step **354**) into memory **84** and thereafter utilized (until further change) in connection with transmission of request signals on frequency f_4 (see, for example, step **214** of FIG. **4**).

The time slot changing sub-routine may also include other operations, if desired, including (for example) eliminating unused time slots (thereby increasing scanning rate); diagnosing and trouble shooting; and avoiding interruption of service from malfunctioning or ill-functioning equipment.

In connection with the transmitter shut down sub-routine, at step **362** microprocessor **80** directs I/O interface **86** to issue an OFF command to transmitter **72**. In connection with the transmitter re-enable sub-routine, at step **372** microprocessor **80** directs I/O interface **86** to issue an ON command to transmitter **72**.

In connection with the clock re-set sub-routine, at step **382** microprocessor **80** directs that clock **59** of pager unit **22** be set.

After execution of steps **354**, **362**, **372**, or **382**, execution continues back to step **304** for processing of potential further communications packets. Thus, unless an error shut-down is noted, each entry of the command processing routine (framed by broken lines **312** in FIG. **5**) is followed by a loop back to step **304**.

FIG. **6** is a timing diagram showing the frequencies f_1–f_4 and integration of the steps depicted in FIGS. **3**–**5**, particularly in the context of a request by a sending pager unit **P1** for sending a message to a sendee pager unit **P2**. As employed in FIG. **6**, "computer" refers to central control station **20**. It should be understood that the sending pager unit **P1** and the sendee pager unit **P2** operate in both the transmission mode as depicted in FIG. **4** and in the receiver mode as depicted in FIG. **5**. In general, FIG. **6** shows transmission of a message from pager unit **P1** (via central control station **20**) to pager unit **P2**; transmission of a confirmation message from pager unit **P2** (via central control station **20**) to pager unit **P1**; and transmission of a message from pager unit **P1** to central control station **20** indicating that pager unit **P1** received the confirmation message from pager unit **P2**.

Structure of Second Embodiment

FIG. **7** shows a central control station **420** according to a second embodiment of the invention; FIG. **8** shows a paging unit **422** suitable for use with central control station **420**.

FIG. **9** shows a wide area paging system including a plurality of central control stations **S1**–**S8** (each identical to central control station **420**), each preferably geographically centered within a respective cell. Each central control station **S1**–**S8** broadcasts its own local frequencies, as well as a set of common or switching frequencies C_1–C_4. The common frequencies C_1–C_4 are broadcast at a lower power, so that reception thereof occurs only in a relatively small neighborhood or common frequency reception region (CFRR) [also referred to as a "switching region"] about the central control station. The local frequencies are broadcast at a significantly greater power for reception substantially throughout the cell. For example, in FIG. **9**, central control station **S1** broadcasts its lower power common frequencies C_1–C_4 to $CFRR_1$ and its higher power local frequencies f_1–f_4 to CELL; central control station **S2** broadcasts its lower power common frequencies C_1–C_4 to $CFRR_2$ and its higher power local frequencies f_5–f_8 to $CELL_2$.

As also shown in FIG. **9**, $CELL_1$ and $CELL_2$ overlap in an overlap region shown in FIG. **9**. Station **S1** utilizes a set of local frequencies f_1–f_4; station **S2** utilizes a different set of local frequencies f_5–f_8. Both stations **S1** and **S2** utilize the same set of common or switching frequencies C_1–C_4. Thus, each central control station utilizes two sets of frequencies, there being four frequencies in each set, resulting in a total of eight frequencies handled per station.

Thus, the second embodiment of the invention is suitable for a system having a plurality of central control stations $\mathbf{420}_x$ where x=1, 2, . . . M. Each central control station $\mathbf{420}_x$ transmits and receives a set of local frequencies f_{L1}, f_{L2}, f_{L3}, f_{L4} in an associated geographical area or cell, as well as the set of common or switch frequencies C_1, C_2, C_3, C_4. While the values of the local frequencies f_{L1}, f_{L2}, f_{L3}, f_{L4}, vary from cell to cell (e.g., differ for differing central control stations $\mathbf{420}_x$), the values of the common or switch frequencies C_1, C_2, C_3, C_4 are uniform through the system (e.g., for all central control stations $\mathbf{420}_x$).

Although not shown in FIG. **9**, it should be understood that the pattern of central control stations repeats in like manner in all compass directions in accordance with the prescribed geographical boundaries of the paging system. Moreover, although not specifically illustrated in FIG. **9**, it should also be understood that each central control station **420** has an associated CFRR.

The common or switching frequencies C_1–C_4 have an analogous function to the corresponding local frequencies f_1–f_4, respectively. In this regard, frequency C_1 carries a clock frequency transmitted by central control station(s), although the clock rate on common frequency C_1 preferably varies among central control stations. Frequency C_2 is used to transmit information from central control station(s) to pager unit(s); frequency C_3 is used to transmit information from a pager unit to a central control station; frequency C_4 is used by pager units to issue a request signal. Frequency C_2 carries packets having a format similar to that of FIG. **12**. In analogous manner to frequency f_2, the packets carried by frequency C_2 may have command codes. Among the C_2 command codes are a SYSTEM COMMAND CODE; a LOCAL FREQUENCY DOWNLOAD COMMAND CODE; a SLOT RECOGNITION COMMAND CODE; and a SLOT ASSIGNMENT COMMAND CODE.

As shown in FIG. **7**, central control station **420** resembles central control station **20** of the embodiment of FIG. **1** (similar components being assigned the same reference numerals for simplicity). However, central control station **420** is augmented by inclusion of a further transmitter, known as common frequency transmitter **432**, together with its common frequency transmission antenna **442**, for transmitting the common frequencies C_1 and C_2. In contrast to the high power transmitter **32**, transmitter **432** is a low power transmitter. Further, central control station **420** is augmented by inclusion of a further receiver, known as the common frequency receiver **434**, together with its common frequency receiver antenna **444**, for reception of the common frequencies C_3 and C_4.

Central control station **420** of FIG. **7** includes a clock unit **59'** which generates two clocking signals—a first or local clocking signal $f_L$clk and a second or common clocking signal $C_f$clk. The local clocking signal $f_L$clk is used to modulate frequency f_1); the common clocking signal is used to modulate the common frequency C_1.

The central computers **30** of the central control stations $\mathbf{420}_x$ are serially connected to one another by an output line **486**A and an input line **486**B. In particular, although not expressly shown as such in FIG. **7**, computer **30** of FIG. **7** (like that of FIG. **1**) includes an I/O interface to which the serial lines **486**A and **486**B are connected. Serial lines **486**A and **486**B are used, for example, to update contents of the pager registration file **55** and the pager directory file **56**.

As shown in FIG. **8**, pager unit **422** resembles pager unit **22** of the embodiment of FIG. **2** (similar components again being assigned the same reference numerals for simplicity). However, pager unit **422** (in like manner as central control station **420**) is augmented by inclusion of a further transmitter, known as common frequency transmitter **572**, together with its common frequency transmission antenna **576**, for transmitting the common frequencies C_3 and C_4. Further, central control station **420** is augmented by inclusion of a further receiver, known as the common frequency receiver **434**, together with its common frequency receiver antenna **444**, for reception of the common frequencies C_1 and C_2.

The operational frequencies of transmitter **72** and receiver **62** are changeable in accordance with values transmitted on "frequency control" lines from computer **70**. In particular, the frequency control lines are connected to I/O interface **86** in computer **70**. As described in more detail below, when a pager unit **422** migrates into a new CFRR, signals are applied on the frequency control lines in order to switch pager unit **422** from the local frequencies of an old cell to the

local frequencies of a new cell associated with the new CFRR into which pager unit **422** migrates.

Pager **422** includes a clock unit **83'** which is capable of separately generating local clocking signals $f_L$clk and the common clocking signals f_{cl}clk for use by microprocessor **80**. These clocking signals are initiated and their frequencies set by appropriate respective inputs to clock unit **83'**.

FIG. **8** also shows that pager unit **422** has data I/O unit **596** which includes both an alphanumeric graphic display and a pressure sensitive writing pad. The alphanumeric graphic display is a dot matrix device which can display characters and graphics. The writing pad has a 16×48 dot area.

OPERATION OF SECOND EMBODIMENT

As shown in FIG. **9**, a pager unit P1 is assumed to have been operating in $CELL_1$ and to have previously received the common frequencies C_1–C_4 and local frequencies f_1–f_2 from station S1. Now pager unit P1 travels on a route indicated by broken arrow-headed line ROUTE. In traveling along the ROUTE, pager unit P1 continues to operate on local frequencies f_1–f_2, even as it travels through the cellular overlap region. However, when page unit P1 enters a new common frequency reception region (i.e., $CFRR_2$), a switching or hand-off operation occurs. In the switching operation, as explained in more detail below, pager unit P1 obtains common frequencies C_1–C_4 from central control station S2 and, as a result, can switch from the local frequencies f_1–f_4 of $CELL_1$ to the local frequencies f_5–f_8 of $CELL_2$. In order to effect the switching or hand-off operation, pager unit P1 executes a channel switching routine; the central control station S2 executes a switching enabling routine.

In connection with the channel switching routine and the switching enabling routine, when pager unit P1 moves into $CFRR_2$, pager unit P1 will receive the clocking signal on frequency C_1 from station S2. At such point, pager unit P1 will automatically align its clock unit with the clocking signal from station S2.

Referring now to the channel switching routine executed by pager P1 subsequent to start-up (step **500**), at step **506** pager unit P1 obtains information characterizing the system centered about station S2. Such characterizing information is referred to as system identification or system ID information.

At step **508**, microprocessor **80** of pager unit P1 checks to determine if there is any new system ID information acquired on frequency C_2. That is, microprocessor **80** checks to determine if system ID information is received on frequency C_2 (which can occur only in a CFRR) and, if so, compares the system ID information to the immediately previously-stored system ID information. If the previous and most recently-acquired system IDs are the same, pager unit P1 realizes that it is still in the jurisdiction of the same station (e.g., station S1). If not, pager unit P1 realizes that it has now wandered into a CFRR of a new station (e.g., station S2) and, at step **510**, initiates a request on frequency C_4 for communication with the central control station (e.g., station S2) for $CELL_2$.

In the above regard, since pager unit P1 has not yet been assigned a time slot for $CELL_2$, the request on frequency C_4 is randomly made. However, pager unit P1 keeps track of the time slot in which it makes its request to the new central control station (e.g., station S2).

Thereafter, pager unit P1 continues to monitor (step **512**) communications packets from station S2 on frequency C_2, waiting for station S2 to issue a message which references the time slot at which pager unit P1 made its request of step **510**. In particular, page unit P1 awaits a message from station S2 on frequency C_2 that includes both a SLOT RECOGNITION COMMAND CODE and information stored in the same time slot which pager unit P1 randomly generated. Since the message including the SLOT RECOGNITION COMMAND CODE includes station S2 as the sender and mirrors the slot randomly generated by pager unit P1, pager unit P1 recognizes the message as being addressed to pager unit P1 and considers issuance of such a message by station S2 (see step **612** of FIG. **11**) to constitute authority for pager unit P1 to communicate further with station S2. In this regard, at step **514** microprocessor **80** of pager unit P1 determines if there is a match between the time slot of a received message and the time slot at which the random request was made at step **510**.

Assuming a match is eventually found at step **514**, at step **516** pager unit P1 sends a communications packet on frequency C_3 to station S2, with the communications packet including the identification or ID of pager unit P1. Using pager registration file **55**, station S2 verifies that the ID of pager unit P1 is a valid ID, and thereafter sends (on frequency C_2) to pager unit P1 a message with the command code LOCAL FREQUENCY DOWNLOAD, which message informs pager unit P1 of the values of the local frequencies handled by station S2 (e.g., frequencies f_5–f_8). Thereafter, as also reflected by step **518**, station S2 sends (on frequency C_2) to pager unit P1 a message with the command code SLOT ASSIGNMENT COMMAND CODE, which message informs pager unit P1 of its slot assignment on frequency f_8. Microprocessor **80** then changes its slot allocation by steps which are similar to those discussed with the afore-mentioned change time slot routine (see steps **350**, **352**, and **354** of FIG. **5**). Step **518** of FIG. **10** reflects reception of the local frequency values and reception of the slot assignment.

After acquisition of all local frequencies and the slot assignment is completed (step **520**), microprocessor **80** implements (at step **522**) a switch to the new local frequencies (e.g., frequencies f_5–f_8). In this regard, microprocessor **80** instructs I/O interface **86** to change transmitter **72** from frequencies f_3, f_4 to frequencies f_7, f_8; and to change receiver **62** from frequencies f_1, f_2 to frequencies f_5, f_6. I/O interface **86** accomplishes the frequency changes by applying appropriate values on the frequency control lines connecting the I/O interface to transmitter **72** and receiver **62**, respectively.

After the switch to new local frequencies at step **522**, microprocessor **80** loops back to step **506**, ultimately to determine when any further switching may be required.

Steps involved in the switching enabling routine executed by a central control station (e.g., station S2) are depicted in FIG. **11**. After start-up (step **600**), CPU **50** determines executes a loop **602** which enables CPU **50** to clean up its pager directory file **56** and to check if any new pager units have wandered into the cell which it administers.

In particular, at step **604** CPU determines whether its central control station (e.g., S2) has been advised by any other central control station (e.g., S3) that a pager unit, formerly under the control of its central control station (e.g., S2), has come under the control of the other central control station (e.g, S3). Such advisement occurs on the serial links connecting the central control stations 420_x, and particularly input serial link **486**B. If such advisement occurs, the ID for the wandered-away pager is deleted from the pager directory file **56** for station S2 (as reflected by steps **606** and **608**).

At step **610**, CPU **50** causes messages with a SYSTEM COMMAND CODE to be transmitted on frequency C_2. As

indicated before, messages transmitted on frequency C_2 include a packet(s) having a format such as that shown in FIG. **12**. The message with the SYSTEM COMMAND CODE particularly includes the central station ID number in its alphanumeric data field.

At step **612**, central control station **420** checks to determine if a request signal has been transmitted by any pager unit **422** on frequency C_4 (as occurred, for example, in context of the discussion of FIG. **10**, particularly step **510**). Such a request signal would likely be issued from a pager unit **422** which has just wandered into the CFRR controlled by the central control station (e.g., into $CFRR_2$ controlled by station S2). If no such request signal is detected, loop **602** is again repeated.

In the event that a request signal is detected at step **612**, central control station **420** notes specifically the time slot on frequency C_4 at which the request occurred (step **614**). At this point, such time slot is the only way central control station **420** can identify the in-wandering pager unit **422**. Central control station **420** desires for the in-wandering pager unit **422** to transmit its identification (ID), but cannot specifically address the in-wandering pager other than with reference to the detected time slot. Accordingly, at step **616**, central control station **420** prepares and transmits a message on frequency C_2 which has a SLOT RECOGNITION COMMAND CODE. The message including the SLOT RECOGNITION COMMAND CODE includes station S2 as the sender and mirrors the slot randomly generated by pager unit P1 (e.g, the time slot at which the in-wandering pager unit **422** issued its request). This transmission on frequency C_2 constitutes authority for pager unit P1 to transmit its identification.

Step **618** denotes acquisition by central control station **420** of the identification (ID) of the in-wandering pager unit **422**. At step **620**, central control station **420** checks its pager registration file **55** to determine if the pager ID is a valid ID. If not, an error message is generated and transmitted (at step **622**), followed by a command for pager unit P1 to shut down (see step **624**).

Assuming that the identification of pager unit **422** was validated at step **620**, CPU **50** checks (at step **630**) its pager directory file **56** to locate an available time slot for the in wandering pager unit **422**, and then associates the available time slot with the ID of the in-wandering pager unit **422**. Then, at step **632**, using a message on frequency C_2 with a LOCAL FREQUENCY DOWNLOAD COMMAND CODE, central control station **420** sends the values of its local frequencies (e.g., f_5, f_6, f_7, f_8) to the in-wandering pager unit **422**. The central control station then (at step **634**) assigns to the in-wandering pager unit **422** a new time slot on its local frequencies using a message on frequency C_2 with a SLOT ASSIGNMENT COMMAND CODE. Processing of the change time slot command by the in-wandering pager unit **422** is understood with analogous reference to FIG. **5**, particularly steps **350**, **352**, and **354**.

Upon completion of step **634**, the in-wandering pager unit **422** is fully initiated into its new cell (e.g., $CELL_2$), and has left the jurisdiction of its former control station (e.g, $CELL_1$ and station S1). Accordingly, at step **636**, CPU **50** requests its I/O interface to issue a command on serial line **486A** which advises (using pager ID) that the in-wandering pager **422** is now under its jurisdiction, so that former jurisdictions (e.g., S1) can delete this pager unit from their pager directory files **56**. Such deletion is understood with reference to steps **604–608** as above-described.

In addition to illustrating geographical location of pager P1, stations S1 and S2, and cells $CELL_1$ and $CELL_2$, FIG. **9** shows the relative timing of communications occurring on common frequencies C_1–C_4. FIG. **9** specifically relates the timing of communications transmissions to specific ones of the aforedescribed steps executed by central control station **420** (the switching enabling routine of FIG. **11**) and by pager unit **422** (the channel switching routine of FIG. **10**).

Although the central control stations $\mathbf{420}_x$ use the same common frequencies C_1–C_4, there is no interference or confusion of these signals transmitted from the control stations $\mathbf{420}_x$. The common frequencies C_1–C_4 are broadcast at a relatively lower power than the local frequencies f_1–f_4 so that reception of the common frequencies C_1–C_4 occurs only in a limited neighborhood (CFRR) about the central control station $\mathbf{420}_x$. Accordingly, pager units **422** traveling through the system receive common frequencies C_1–C_4 only in the limited and non-overlapping CFRRs.

System operational characteristics, such as cell diameter, CFRR diameter, power level of the local frequencies (e.g., f_1–f_4), and power level of the common frequencies (C_1–C_4) can be field adjusted to suit numerous factors, including particularly the terrain and topography of the geographical region covered by the system. By way of non-limiting example, in one embodiment, the radius of each cell is on the order of about 20 miles; while the radius of each CFRR is on the order of about 10 miles or less. In the same example, the power for transmission of the local frequencies can be in a range of from about 3 watts to 1000 watts; while the power for transmission of the common frequencies C_1–C_4 is preferably less than 2 watts.

Thus, the invention provides a two-way paging system which operates independently from a telephone system for wireless data communication between users. The invention minimizes use of available frequencies allowed by the Federal Communications Commission (FCC), using only four local frequencies f_1–f_4 for any given cell and (for expanded, multi-cellular coverage) only four common or switching frequencies C_1–C_4. In order to minimize the number of frequencies (e.g, channels) utilized, techniques of time division sharing and synchronization are employed. A transmission power differential between the local frequencies and the common frequencies is also employed. These techniques allow data transmission to be kept separate from different pagers and thus eliminates merging of data.

The switching technique of the present invention provides extended geographical coverage and minimizes paging time by increasing the number of frequencies utilized in a cell from four (e.g, the four local frequencies) to eight (the four local frequencies plus the four common frequencies).

In connection with verification of pager ID, it should be understood that a single pager registration file might be stored in a memory file only one of a plurality of central control stations, and that in such case verification would constitute issuing a search command (on the serial links **486**) to locate a pager ID in the one (remote) memory file, with the results of the search being reported back to the inquiring central control station.

The keyboards illustrated herein can, in some embodiments, be multi-language keyboards or writing pads which permit typing of English, Chinese, or Japanese languages, for example. The writing pad is especially useful in countries such as Japan, Thailand, the middle East or China where English-like alphabets are not used. The writing pad could also be used to sketch and transmit graphics. Moreover, data compression/de-compression techniques can be utilized in connection with data transfer.

While the invention has been particularly shown and described with reference to the preferred embodiments

thereof, it will be understood by those skilled in the art that various alterations in form and detail may be made therein without departing from the spirit and scope of the invention. For example, it should be understood that repeaters may be employed within cells to facilitate transmission when a pager unit ventures far from a central control station.

What is claimed is:

1. A method of communicating data comprising:

receiving a first signal transmitted from a communication controller at a first network node, the first signal including information relating to at least one timeslot in which the first node may transmit a request signal to the communication controller;

transmitting from the first node to the communication controller the request signal in response to receipt of the first signal, the request signal including a request for allocation of time for transmitting a specified amount of data from the first node to the communication controller;

receiving a second signal from the communication controller transmitted to the first node in response to the request signal, said second signal including information specifying at least one timeslot allocated to the first node for transmitting the data to the communication controller; and

transmitting the data from the first node to the communication controller in response to the second signal.

2. The method of claim 1, wherein said first signal received by the first node from the communication controller includes information specifying at least one frequency allocated to the first node for transmitting its request signal.

3. The method of claim 1, wherein said second signal includes information specifying at least one frequency allocated to the first node for transmitting the data to the communication controller.

4. The method of claim 1, wherein the first node transmits randomly generated information to the communication controller.

5. The method of claim 4, wherein said randomly generated information may be generated by the first node.

6. The method of claim 4, wherein said randomly generated information is randomly generated identification information.

7. The method of claim 6, wherein said randomly generated identification information is at least temporarily associated with the first node.

8. The method of claim 4, wherein said randomly generated information is time derived identifying information which is at least temporarily associated with the first node.

9. The method of claim 1, wherein the first node is at least in part defined by the cell where the first node is transmitting, at least in part by defined by the at least one frequency the first node is transmitting over and at least in part defined by the at least one timeslot the first node is transmitting in.

10. The method of claim 1, wherein the communication controller transmits randomly generated information to the first node.

11. The method of claim 4, wherein the communication controller transmits randomly generated information back to the first node.

12. The method of claim 10, further comprising the step of: transmitting node identification information from the first node to the communication controller subsequent to the first node receiving said randomly generated information from the communication controller.

13. The method of claim 1, wherein the data transmitted by the first node comprises an amount of data comprising at least one data packet, wherein said at least one data packet comprises information relating to a number of related data packets making up the data transmitted by the first node.

14. The method of claim 13, wherein the information relating to the number of related packets is a countdown value.

15. The method of claim 13, wherein the last data packet of the amount of data transmitted by the first node contains information indicating that the last data packet is the final data packet.

16. The method of claim 1, wherein the at least one timeslot in which the first node may transmit the request signal is one of a series of timeslots where the network nodes can transmit requests, the series of timeslots occurring repeatedly after transmission of the first signal from the communication controller and continuing after receipt of the request signal transmitted to the communication controller.

17. The method of claim 16, wherein the series of timeslots where the network nodes can transmit requests occurs repeatedly without being disabled during operation of the communication controller.

18. The method of claim 1, wherein the at least one timeslot allocated by the communication controller to the first node in the second signal is assigned exclusively to the first node.

19. The method of claim 18, wherein the at least one timeslot allocated by the communication controller to the first node is an allocation of at least one timeslot within at least one frequency.

20. The method of claim 1, wherein said request signal is transmitted from the first node to the communication controller via a channel comprised of at least one timeslot within at least one frequency,

wherein said first signal is transmitted from the communication controller to the first node via a channel comprised of at least one timeslot within at least one frequency,

wherein said second signal is transmitted from the communication controller to the first node via a channel comprised of at least one timeslot within at least one frequency,

wherein said data is transmitted from the first node to the communication controller via a channel comprised of at least one timeslot within at least one frequency,

wherein the request signal may be provided on a separate channel than the data within a frequency,

wherein the first signal may be provided on a separate channel than the second signal within a frequency, and

wherein the number of timeslots and frequencies utilized for communication between the first node and the communication controller need not be fixed.

21. The method of claim 1, wherein the first signal transmitted from the communication controller to the at least one network node including the first node is transmitted on a common control channel, wherein said common control channel is at least one timeslot within at least one frequency wherein the communication controller transmits information to at least one network node including the first node regarding random access timeslot request opportunities.

22. The method of claim 1, wherein the request signal transmitted from the first node to the communication controller is transmitted on a common control channel, wherein said common control channel is at least one timeslot within at least one frequency wherein at least one network node including the first node may transmit a random access request signal.

23. The method of claim 1, wherein the second signal is transmitted from the communication controller to the first node on a common control channel, wherein said common control channel is at least one timeslot within at least one frequency wherein the communication controller transmits timeslot assignment information.

24. The method of claim 1, wherein the data transmitted from the first node to the communication controller is transmitted on at least one dedicated channel, wherein said at least one dedicated channel is at least one timeslot within at least one frequency assigned exclusively to a node for transmitting data to the communication controller.

25. The method of claim 1, wherein the first signal is a recurring signal transmitted from the communication controller to at least one network node,

wherein transmissions between the communication controller and a plurality of network nodes may occur simultaneously over at least one frequency,

wherein the state of operation for each relative node of the plurality of nodes comprises at least a first state for monitoring for a first signal from the communication controller, at least a second state for transmitting a request signal from the relative node to the communication controller, at least a third state for monitoring for a second signal from the communication controller and at least a fourth state for transmitting data, and

wherein the relative state for each relative node from the plurality of nodes is determined by the associated state of operation for each relative node.

26. The method of claim 25, wherein each relative node from the plurality of nodes may operate at a different relative state of operation for each relative node in relation to other nodes from the plurality of nodes.

27. The method of claim 25, wherein the state of operation for each relative node comprises at least one other state for receiving incoming data transmissions from the communication controller.

28. The method of claim 25, wherein the state of operation also comprises at least one other state for receiving data transmissions from the communication controller.

29. The method of claim 27, wherein a node may operate in more than one state at any given period.

30. The method of claim 29, wherein a node may simultaneously send and receive transmissions.

31. The method of claim 1, further comprising:

receiving an additional first signal transmitted from a communication controller at a second node, the additional first signal including information relating to at least one timeslot in which the second node may transmit a request signal to the communication controller;

transmitting the additional request signal from the second node to the communication controller, said additional request signal transmitted from the second node to the communication controller in response to the second node receiving the additional first signal, the additional request signal including a request for allocation of time for transmitting a specified amount of additional data from the second node to the communication controller;

receiving an additional second signal from the communication controller transmitted to the second node in response to the communication controller receiving the additional request signal from the second node, said additional second signal including information specifying at least one timeslot allocated to the second node for transmitting the additional data to the communication controller; and

transmitting the additional data transmitted from the second node to the communication controller.

32. The method of claim 31, wherein said additional first signal transmitted from the communication controller to the second node is transmitted at any time after the communication controller has transmitted the first signal from the communication controller to the first node.

33. The method of claim 32, wherein the transmissions from and subsequent signal receptions by the second node after receipt of said additional first signal from the communication controller may occur at any time after the communication controller has transmitted the first signal from the communication controller to the first node, including at least any time prior to the communication controller receiving all the data transmitted from the first node.

34. The method of claim 31, wherein said additional request signal transmitted from the second node to the communication controller includes information randomly generated by the second node.

35. The method of claim 31, wherein said second signal transmitted from the communication controller to the second node includes said information randomly generated by the second node.

36. The method of claim 31, wherein said additional first signal received by the second node from the communication controller includes information specifying at least one frequency allocated to the second node for transmitting the additional request signal.

37. The method of claim 31, wherein said second additional signal includes information specifying at least one frequency allocated to the second node for transmitting the additional data to the communication controller.

38. The method of claim 31, wherein the at least one timeslot allocated by the communication controller to the second node in the additional second signal is assigned exclusively to the second node.

39. The method of claim 38, wherein the at least one timeslot allocated by the communication controller to the second node is an allocation of at least one timeslot within at least one frequency.

40. The method of claim 31, wherein said additional request signal is transmitted from the second node to the communication controller via a channel comprised of at least one timeslot within at least one frequency,

wherein said additional first signal is transmitted from the communication controller to the second node via a channel comprised of at least one timeslot within at least one frequency,

wherein said additional second signal is transmitted from the communication controller to the second node via a channel comprised of at least one timeslot within at least one frequency,

wherein said additional data is transmitted from the second node to the communication controller via a channel comprised of at least one timeslot within at least one frequency,

wherein the additional request signal may be provided on a separate channel than the additional data within a frequency,

wherein the additional first signal may be provided on a separate channel than the additional second signal within a frequency, and

wherein the number of timeslots and frequencies utilized for communication between the second node and the communication controller need not be fixed.

41. The method of claim 31, wherein the second node receives information transmitted from the communication

controller relating to at least one frequency the second node must utilize in transmitting the additional data to and receiving data from the communication controller.

42. The method of claim **41**, wherein the second node receives information from the communication controller relating to at least one frequency wherein the second node is assigned to transmit.

43. The method of claim **42**, wherein the information relating to at least one frequency wherein the second node is assigned to transmit is information relating to at least one frequency wherein the second node is assigned to transmit the additional data.

44. The method of claim **42**, wherein the information relating to at least one frequency wherein the second node is assigned to transmit is information relating to at least one frequency wherein the second node is assigned to transmit the additional request signal.

45. The method of claim **42**, wherein the second node receives information from the communication controller relating to an assignment of at least one timeslot within at least one frequency wherein the second node is assigned to transmit.

46. The method of claim **45**, wherein the information relating to at least one timeslot within the at least one frequency wherein the second node is assigned to transmit is information relating to at least one timeslot within the at least one frequency wherein the second node is assigned to transmit the additional data.

47. The method of claim **45**, wherein the information relating to at least one timeslot within the at least one frequency wherein the second node is assigned to transmit is information relating to at least one timeslot within the at least one frequency wherein the second node is assigned to transmit the additional request signal.

48. The method of claim **45**, wherein the second node transmits within at least one timeslot within the at least one frequency.

49. The method of claim **31**, wherein any number of frequencies may be used for transmissions between the communication controller and the second node.

50. The method of claim **49**, wherein the number of frequencies used for transmissions between the communication controller and the second node need not be fixed.

51. The method of claim **1**, wherein the first node includes a writing pad for entering the data into the node.

52. The method of claim **51**, wherein the writing pad is pressure sensitive.

53. The method of claim **1**, wherein the first node receives information transmitted from the communication controller relating to at least one frequency the first node must utilize in transmitting data to and receiving data from the communication controller.

54. The method of claim **53**, wherein the first node receives information from the communication controller relating to at least one frequency wherein the first node is assigned to transmit.

55. The method of claim **54**, wherein the information relating to at least one frequency wherein the first node is assigned to transmit is information relating to at least one frequency wherein the first node is assigned to transmit data.

56. The method of claim **54**, wherein the information relating to at least one frequency wherein the first node is assigned to transmit is information relating to at least one frequency wherein the first node is assigned to transmit a request signal.

57. The method of claim **54**, wherein the first node receives information from the communication controller relating to an assignment of at least one timeslot within at least one frequency wherein the first node is assigned to transmit.

58. The method of claim **57**, wherein the information relating to at least one timeslot within at least one frequency wherein the first node is assigned to transmit is information relating to at least one timeslot within at least one frequency wherein the first node is assigned to transmit data.

59. The method of claim **57**, wherein the information relating to at least one timeslot within at least one frequency wherein the first node is assigned to transmit is information relating to at least one timeslot within at least one frequency wherein the first node is assigned to transmit a request signal.

60. The method of claim **57**, wherein the first node transmits within at least one timeslot within at least one frequency.

61. The method of claim **53**, wherein the first node receives information relating to at least one frequency wherein the first node must monitor for transmissions from the communication controller.

62. The method of claim **61**, wherein the first node receives transmissions from the communication controller on at least one frequency.

63. The method of claim **61**, wherein the first node receives transmissions from the communication controller in at least one timeslot within at least one frequency.

64. The method of claim **53**, wherein the at least one frequency comprises a list of frequencies the first node must utilize in transmitting data to and receiving data from the communication controller.

65. The method of claim **53**, wherein the at least one frequency comprises a range of frequencies wherein the first node must utilize in transmitting data to and receiving data from the communication controller.

66. The method of claim **53**, wherein the first node transmits within at least one timeslot within at least one frequency when transmitting data to and receiving data from the communication controller, and

wherein the first node receives transmissions from the communication controller in at least one timeslot within at least one frequency when transmitting data to and receiving data from the communication controller.

67. The method of claim **66**, wherein the at least one frequency utilized in transmitting data from the first node to the communication controller can be changed.

68. The method of claim **66**, wherein the at least one frequency the first node transmits and the at least one frequency the first node receives transmissions from the communication controller comprises at least one range of frequencies utilized by the first node in transmitting data to and receiving data from the communication controller,

wherein at least one frequency forming the at least one range of frequencies utilized by the first node in transmitting data to and receiving data from the communication controller is changed.

69. The method of claim **66**, wherein the first node determines which of the at least one frequency the first node will utilize in communicating with the communication controller.

70. The method of claim **68**, wherein at least one frequency is changed via switching of the at least one frequency.

71. The method of claim **70**, wherein at least one frequency utilized for switching the may be predetermined.

72. The method of claim 70, wherein the first node determines whether switching of the at least one frequency is required based upon signal quality.

73. The method of claim 70, wherein the communication controller controls whether switching of the at least one frequency is required based upon signal quality.

74. The method of claim 66, wherein the communication controller assigns at least one frequency for the first node to utilize in communicating with the communication controller.

75. The method of claim 74, wherein the communication controller assigns at least one frequency to the first node for frequency switching.

76. The method of claim 75, wherein the first node is assigned at least one timeslot within at least one frequency by the communication controller to transmit.

77. The method of claim 66, wherein the first node transmits data to and receives data from the communication controller via at least one antenna.

78. The method of claim 77, wherein the at least one antenna comprises multiple antennas.

79. The method of claim 1, wherein any number of frequencies may be used for transmissions between the communication controller and the first node.

80. The method of claim 79, wherein the number of frequencies used for transmissions between the communication controller and the first node need not be fixed.

81. The method of claim 1, wherein the first node receives information from the communication controller assigning a new timeslot for transmitting.

82. The method of claim 1, wherein the first node randomly chooses at least one timeslot wherein the first node transmits.

83. The method of claim 18, wherein the at least one timeslot assigned to the first node need not be fixed.

84. The method of claim 1, wherein the communication controller transmits at least one acknowledgment in response to receiving at least one transmission from the first node.

85. The method of claim 18, wherein the communication controller maintains radio resources allocated to the first node after the data from the first node has been received, wherein said radio resources comprise at least one timeslot assigned to the first node for the first node to further communicate with the communication controller, wherein the communication controller may remove the at least one timeslot assigned to the first node when the at least one timeslot assigned to the first node is unused by the first node for a predetermined period of time.

86. The method of claim 1, wherein the first node communicates with at least one communication controller in at least one time slot via at least one antenna via at least one frequency.

87. The method of claim 86, wherein the at least one antenna comprises multiple antennas.

88. The method of claim 86, wherein said multiple antennas comprises at least one antenna for transmitting signals from the first node to at least one communication controller over at least one frequency in at least one time slot.

89. The method of claim 86, wherein said at least one communication controller comprises multiple communication controllers, wherein said at least one frequency comprises multiple frequencies.

90. The method of claim 86, wherein said multiple antennas comprises at least one antenna for receiving signals from at least one communication controller over at least one frequency.

91. The method of claim 86, wherein said at least one communication controller comprises multiple communication controllers, wherein said at least one frequency comprises multiple frequencies.

92. The method of claim 86, wherein the node may transmit signals and receive signals at the same time.

93. The method of claim 92, wherein the first node may simultaneously transmit signals on multiple frequencies, and wherein the first node may simultaneously receives transmissions on multiple frequencies.

94. The method of claim 93, wherein the first node may transmit a request signal to at least one communication controller while transmitting data to at least one communication controller.

95. The method of claim 1, wherein the first node simultaneously transmits and receives signals with at least one communication controller over any number of antennas over any number of frequencies.

96. The method of claim 1, wherein a communication controller comprises a communication device capable of receiving and transmitting signals to at least one other communication device over any number of frequencies.

* * * * *

EXHIBIT C

US007209748B2

(12) **United States Patent**
Wong et al.

(10) **Patent No.: US 7,209,748 B2**
(45) **Date of Patent: *Apr. 24, 2007**

(54) **NETWORK COMMUNICATION SYSTEM USING A SINGLE RESERVATION REQUEST OVER ONE OR MORE ASSIGNED FREQUENCIES TO IDENTIFY A NODE**

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(73) Assignee: **GPNE Corp.**, Honolulu, HI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

(60) Continuation of application No. 11/350,616, filed on Feb. 8, 2006, which is a continuation of application No. 09/847,005, filed on May 2, 2001, now Pat. No. 7,031,716, which is a continuation of application No. 09/594,662, filed on Jun. 15, 2000, now Pat. No. 6,282,406, which is a continuation of application No. 09/259,417, filed on Dec. 9, 1997, now Pat. No. 6,108,520, which is a continuation of application No. 08/608,629, filed on Feb. 29, 1996, now Pat. No. 5,729,827, which is a division of application No. 08/264,973, filed on Jun. 24, 1994, now Pat. No. 5,542,115.

(51) **Int. Cl.**
H04Q 7/20 (2006.01)
H04Q 7/00 (2006.01)

(52) **U.S. Cl.** **455/450**; 455/509; 455/510; 455/515; 455/516; 455/517; 370/330; 370/336; 370/350; 340/7.2; 340/7.21

(58) **Field of Classification Search** 455/450, 455/509, 510, 515, 516, 517; 370/330, 336, 370/350; 340/7.2, 7.21
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,224,150 A 9/1980 Buriks et al. 210/735
4,345,491 A 8/1982 Hannon 74/831

(Continued)

OTHER PUBLICATIONS

Bertsekas, Dimitri, and Gallagher, Robert, Data Networks, pp. 312-317 (Prentice-Hall, Inc., Upper Saddle River, New Jersey 07458, 2nd ed. 1992).

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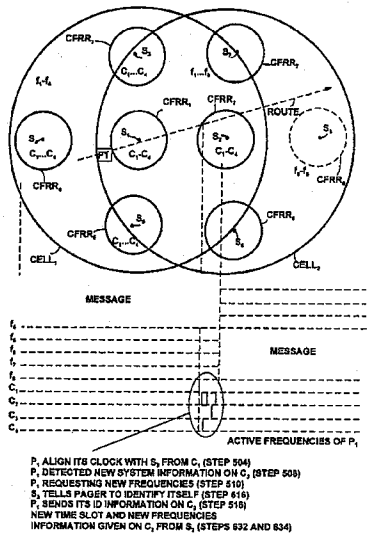
(74) *Attorney, Agent, or Firm*—Fliesler Meyer LLP

(57) **ABSTRACT**

A network communication system is provided for communication between network nodes, including individual nodes and a central control station node. In the network, signals are transmitted from the central control node to identify one or more frequencies that the node may transmit. When a first individual node has data to transmit, the first individual node transmits a request signal to the central control node over one or more of its assigned frequencies. In response to the request signal, the central control node transmits a grant signal assigning one or more frequencies to allow the first node to transmit its data.

112 Claims, 13 Drawing Sheets



U.S. PATENT DOCUMENTS

4,644,347	A	2/1987	Lucas et al.	340/825.04
4,644,351	A	2/1987	Zabarsky et al.	340/825.44
RE32,365	E	3/1987	Sebestyen	
4,713,808	A	12/1987	Gaskill et al.	370/94
4,747,122	A	5/1988	Bhagat et al.	379/57
4,823,123	A	4/1989	Siwiak	340/825.44
4,845,491	A	7/1989	Fascenda et al.	340/825.44
4,870,402	A	9/1989	DeLuca et al.	340/825.44
4,875,038	A	10/1989	Siwiak et al.	340/825.44
4,882,579	A	11/1989	Siwiak	340/825.44
4,914,649	A	4/1990	Schwendeman et al.	370/50
4,940,963	A	7/1990	Gutman et al.	340/313
RE33,417	E	10/1990	Bhagat et al.	
4,978,944	A	12/1990	Andros et al.	340/825.44
5,012,469	A	4/1991	Sardana	370/95.3
5,043,721	A	8/1991	May	340/825.44
5,086,501	A	2/1992	DeLuca et al.	395/550
5,109,400	A	4/1992	Patsiokas et al.	379/57
5,111,197	A	5/1992	Ichikawa	340/825.44
5,117,449	A	5/1992	Metroka et al.	379/58
5,142,279	A	8/1992	Jasinski et al.	340/825.44
5,153,580	A	10/1992	Pollack	340/825.25
5,170,487	A	12/1992	Peek	455/45
5,197,125	A	3/1993	Engel et al.	395/200
5,206,855	A	4/1993	Schwendeman et al.	370/50
5,224,150	A	6/1993	Neustein	379/57
5,247,700	A	9/1993	Wohl et al.	455/33.1
5,260,986	A	11/1993	Pershan	379/57
5,261,118	A	11/1993	Vanderspool, II et al.	455/51.2
5,276,703	A	1/1994	Budin et al.	375/1
5,278,833	A	1/1994	Crisler et al.	370/95.1
5,285,496	A	2/1994	Frank et al.	380/9
5,297,144	A	3/1994	Gilbert et al.	370/95.2
5,396,496	A	3/1995	Ito et al.	370/50
5,396,537	A	3/1995	Schwendenman et al.	379/57
5,463,675	A	10/1995	Gerszberg	379/60
5,485,463	A	1/1996	Godoroja	370/95.1
5,491,469	A	2/1996	Schwendeman	340/825.04
5,521,925	A	5/1996	Merakos et al.	370/95.3
5,542,115	A	7/1996	Wong et al.	455/53.1
5,680,398	A	10/1997	Robinson	370/458
6,108,520	A	8/2000	Wong et al.	455/31.3
6,282,406	B1	8/2001	Wong et al.	455/31.3

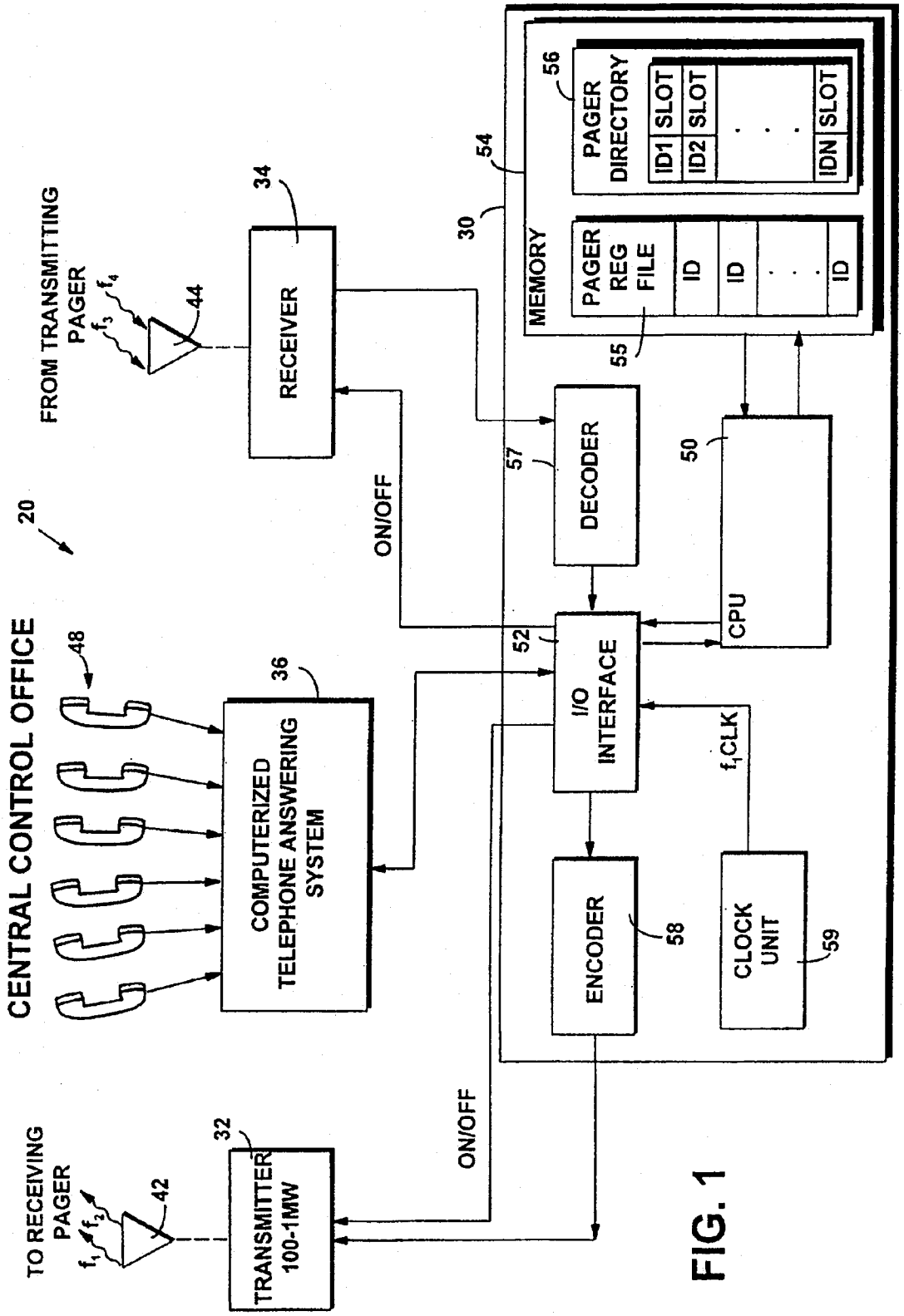

CENTRAL CONTROL OFFICE
20
FROM TRANSMITTING PAGER
f_3 f_4
44
RECEIVER
34
ON/OFF
MEMORY
30
PAGER DIRECTORY
56
54
ID1 SLOT
ID2 SLOT
IDN SLOT
PAGER REG FILE
55
ID
ID
ID
57
DECODER
50
CPU
52
I/O INTERFACE
f_1CLK
48
36
COMPUTERIZED TELEPHONE ANSWERING SYSTEM
ENCODER
58
CLOCK UNIT
59
ON/OFF
TO RECEIVING PAGER
f_1 f_2
42
32
TRANSMITTER 100-1MW

FIG. 1

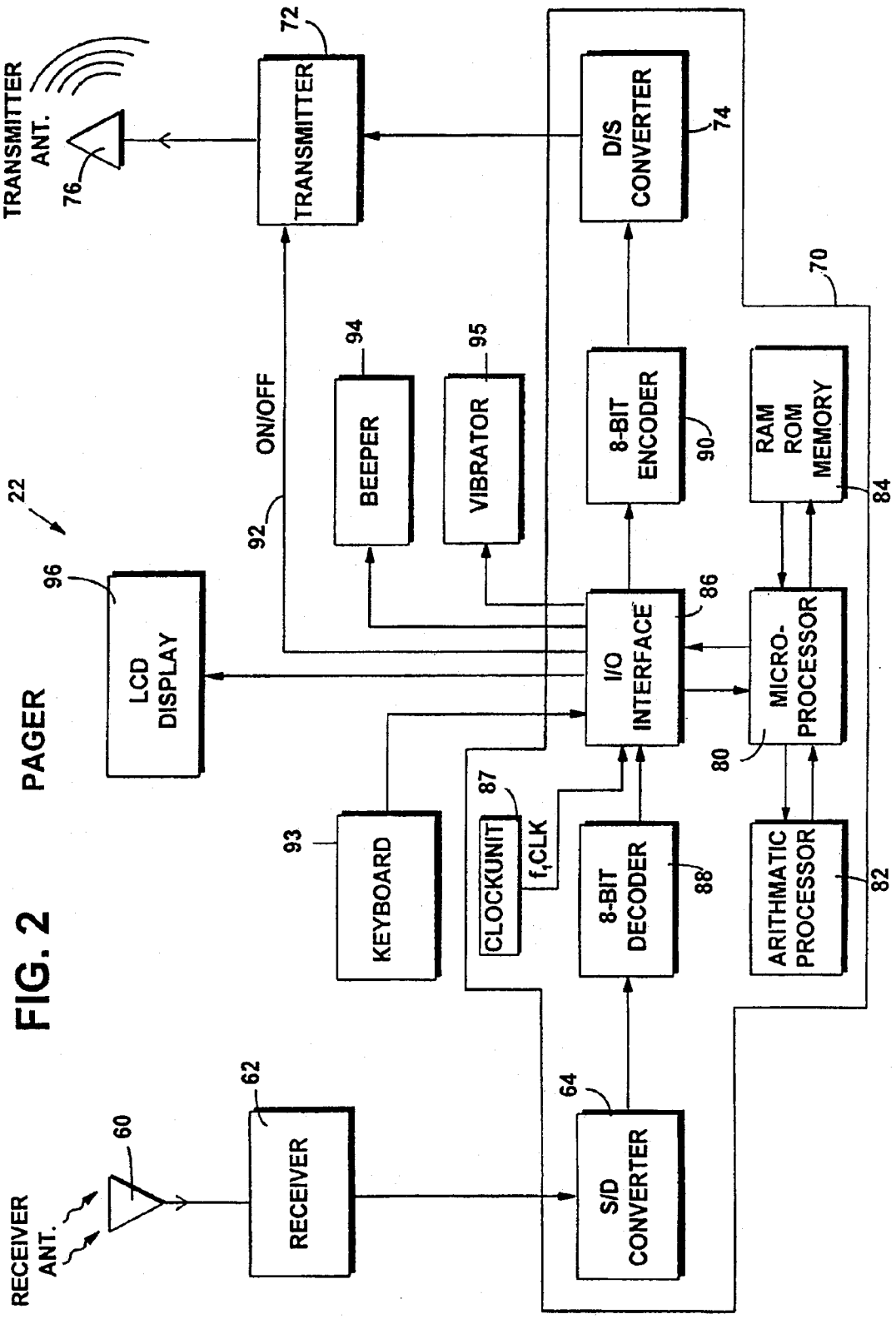
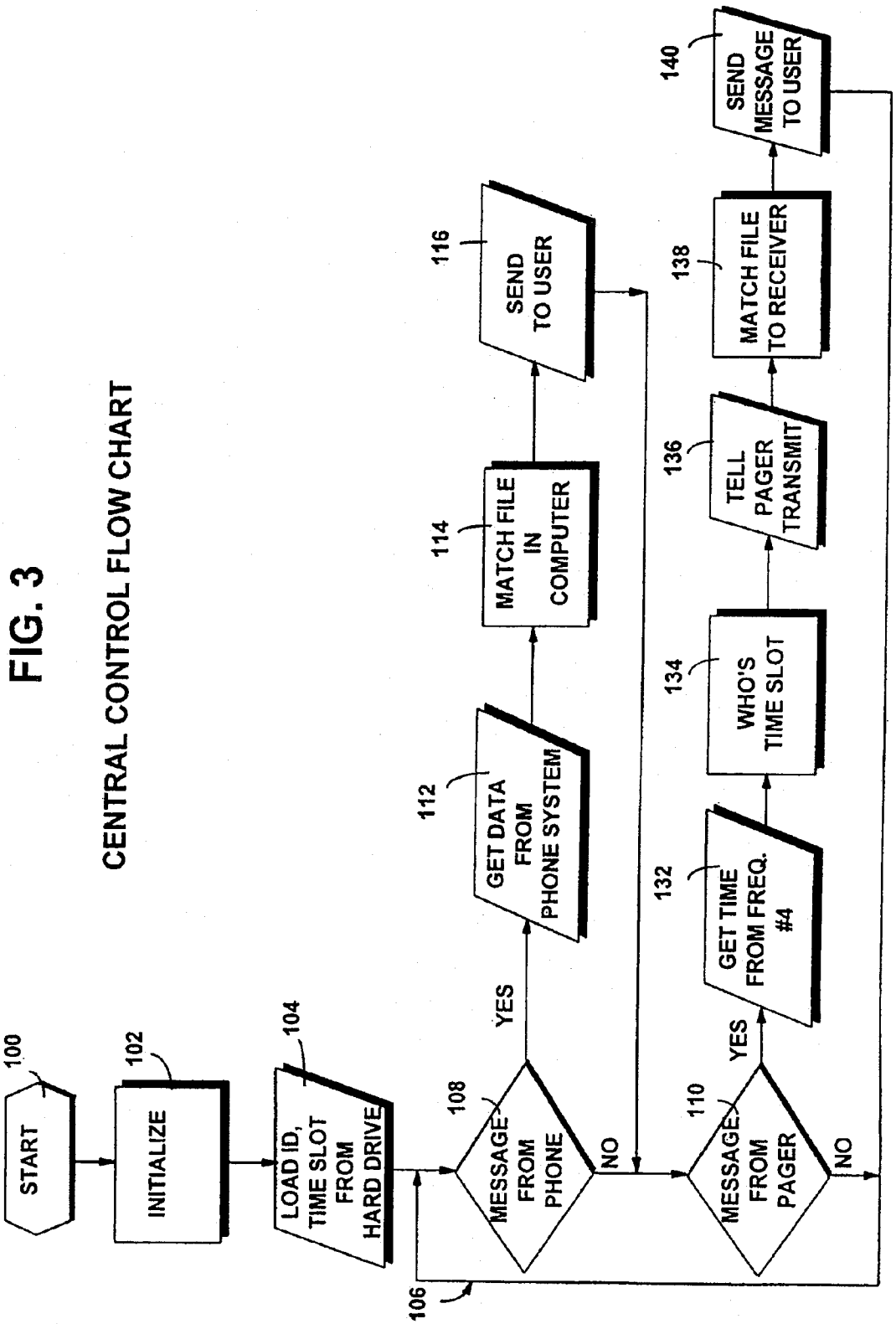

TRANSMITTER ANT.
76
72
TRANSMITTER
D/S CONVERTER
74
70
ON/OFF
92
94
BEEPER
95
VIBRATOR
8-BIT ENCODER
90
RAM ROM MEMORY
84
22
PAGER
96
LCD DISPLAY
I/O INTERFACE
86
MICRO-PROCESSOR
80
87
CLOCKUNIT
f,CLK
93
KEYBOARD
8-BIT DECODER
88
ARITHMATIC PROCESSOR
82
62
60
RECEIVER ANT.
RECEIVER
64
S/D CONVERTER

FIG. 2

FIG. 3

CENTRAL CONTROL FLOW CHART



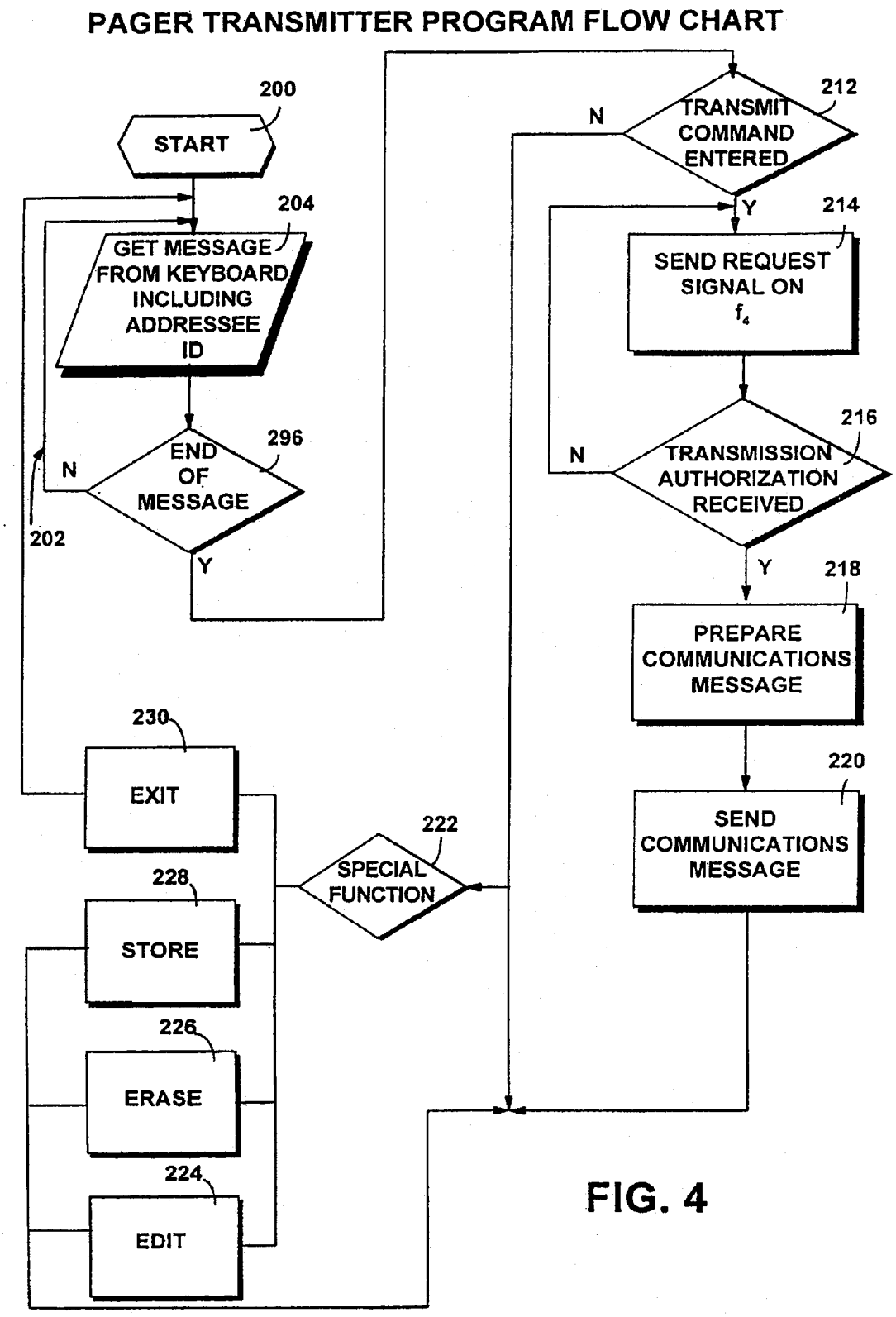

PAGER TRANSMITTER PROGRAM FLOW CHART
200
START
204
GET MESSAGE FROM KEYBOARD INCLUDING ADDRESSEE ID
296
END OF MESSAGE
N
Y
202
212
TRANSMIT COMMAND ENTERED
N
Y
214
SEND REQUEST SIGNAL ON f_4
216
TRANSMISSION AUTHORIZATION RECEIVED
N
Y
218
PREPARE COMMUNICATIONS MESSAGE
220
SEND COMMUNICATIONS MESSAGE
222
SPECIAL FUNCTION
230
EXIT
228
STORE
226
ERASE
224
EDIT

FIG. 4

FIG. 5

PAGER RECEIVER PROGRAM FLOW CHART

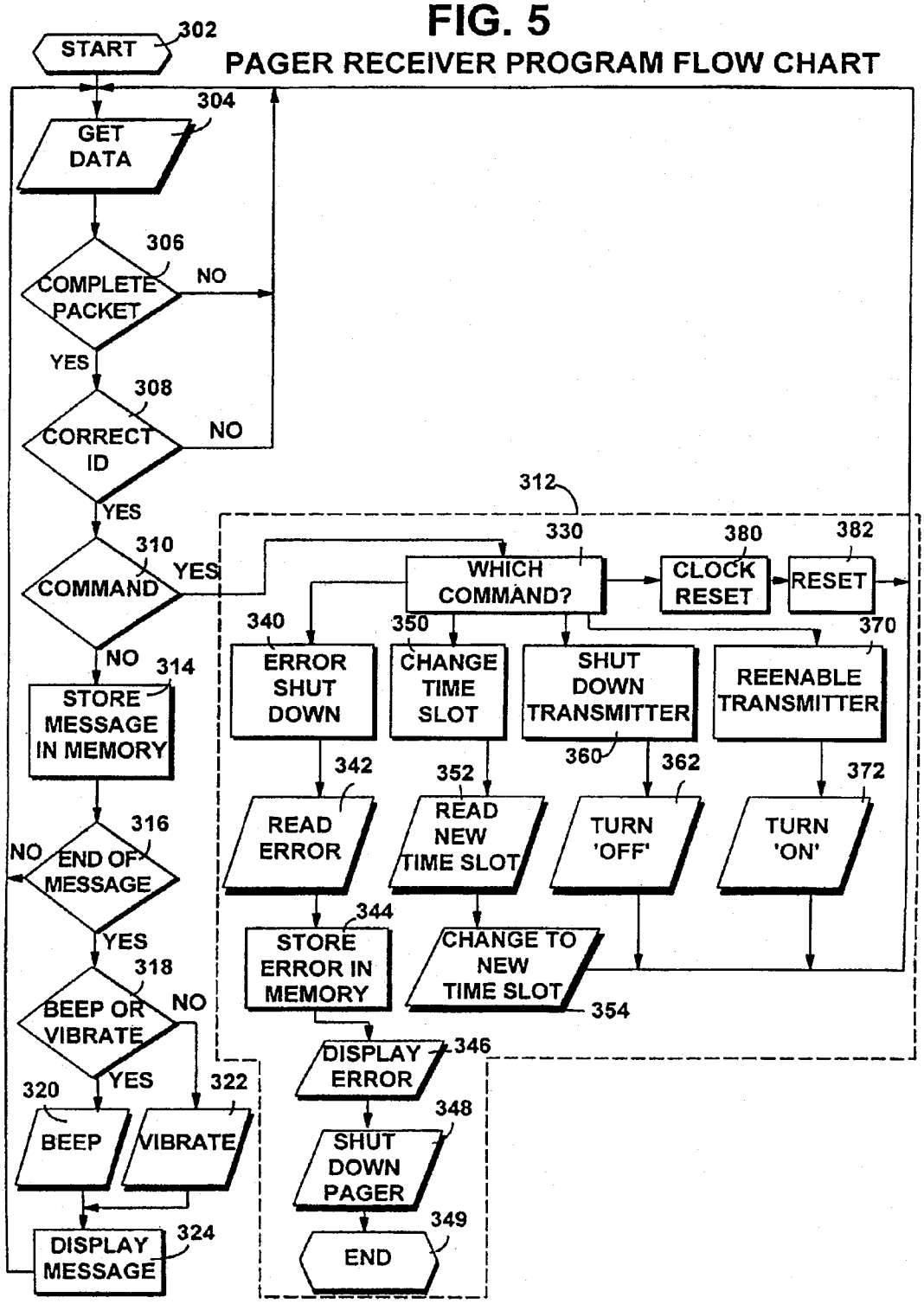


FIG. 6

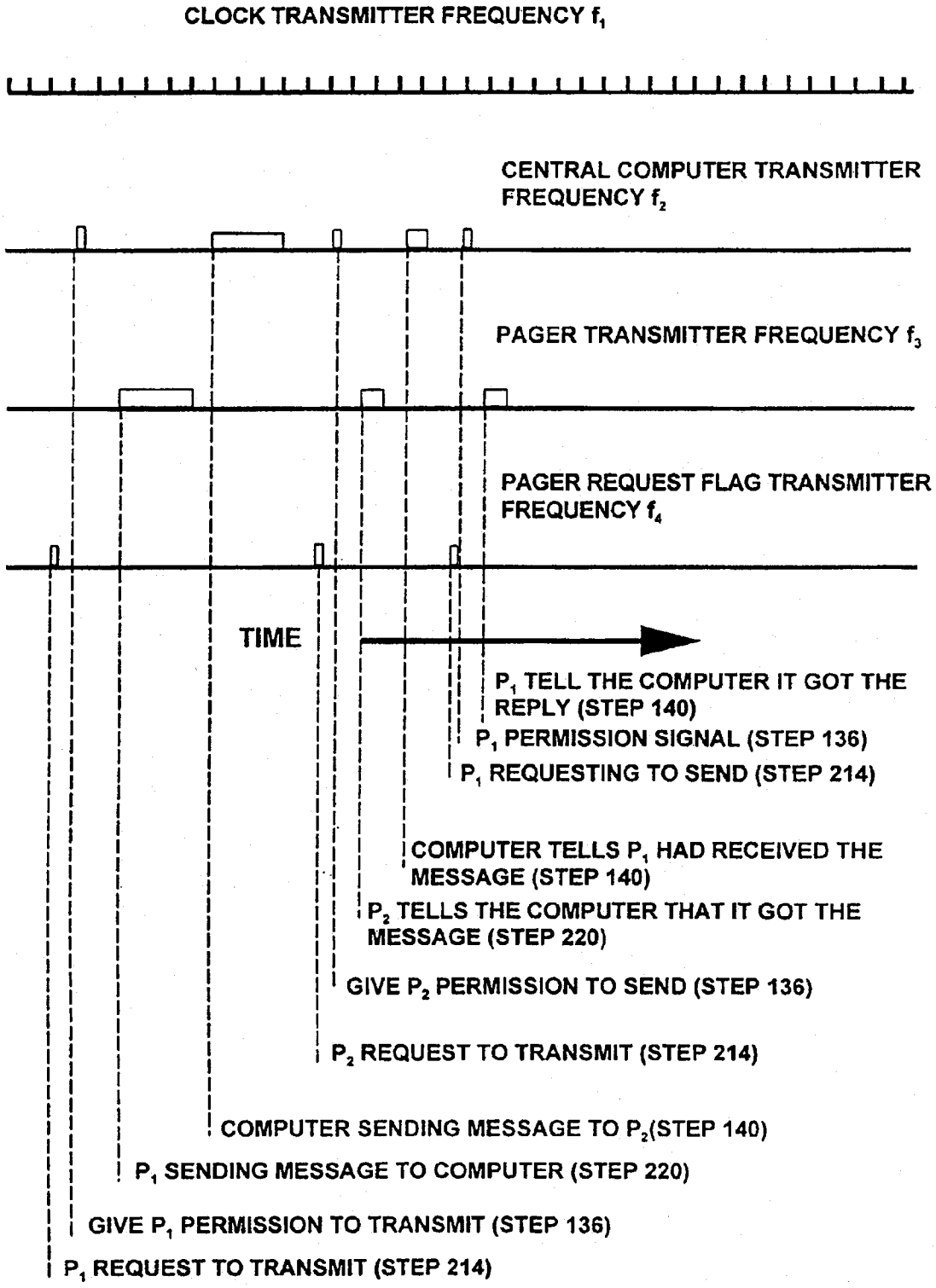

CLOCK TRANSMITTER FREQUENCY f_1
CENTRAL COMPUTER TRANSMITTER FREQUENCY f_2
PAGER TRANSMITTER FREQUENCY f_3
PAGER REQUEST FLAG TRANSMITTER FREQUENCY f_4
TIME
P_1 TELL THE COMPUTER IT GOT THE REPLY (STEP 140)
P_1 PERMISSION SIGNAL (STEP 136)
P_1 REQUESTING TO SEND (STEP 214)
COMPUTER TELLS P_1 HAD RECEIVED THE MESSAGE (STEP 140)
P_2 TELLS THE COMPUTER THAT IT GOT THE MESSAGE (STEP 220)
GIVE P_2 PERMISSION TO SEND (STEP 136)
P_2 REQUEST TO TRANSMIT (STEP 214)
COMPUTER SENDING MESSAGE TO P_2(STEP 140)
P_1 SENDING MESSAGE TO COMPUTER (STEP 220)
GIVE P_1 PERMISSION TO TRANSMIT (STEP 136)
P_1 REQUEST TO TRANSMIT (STEP 214)

FIG. 7

CENTRAL OFFICE LAYOUT

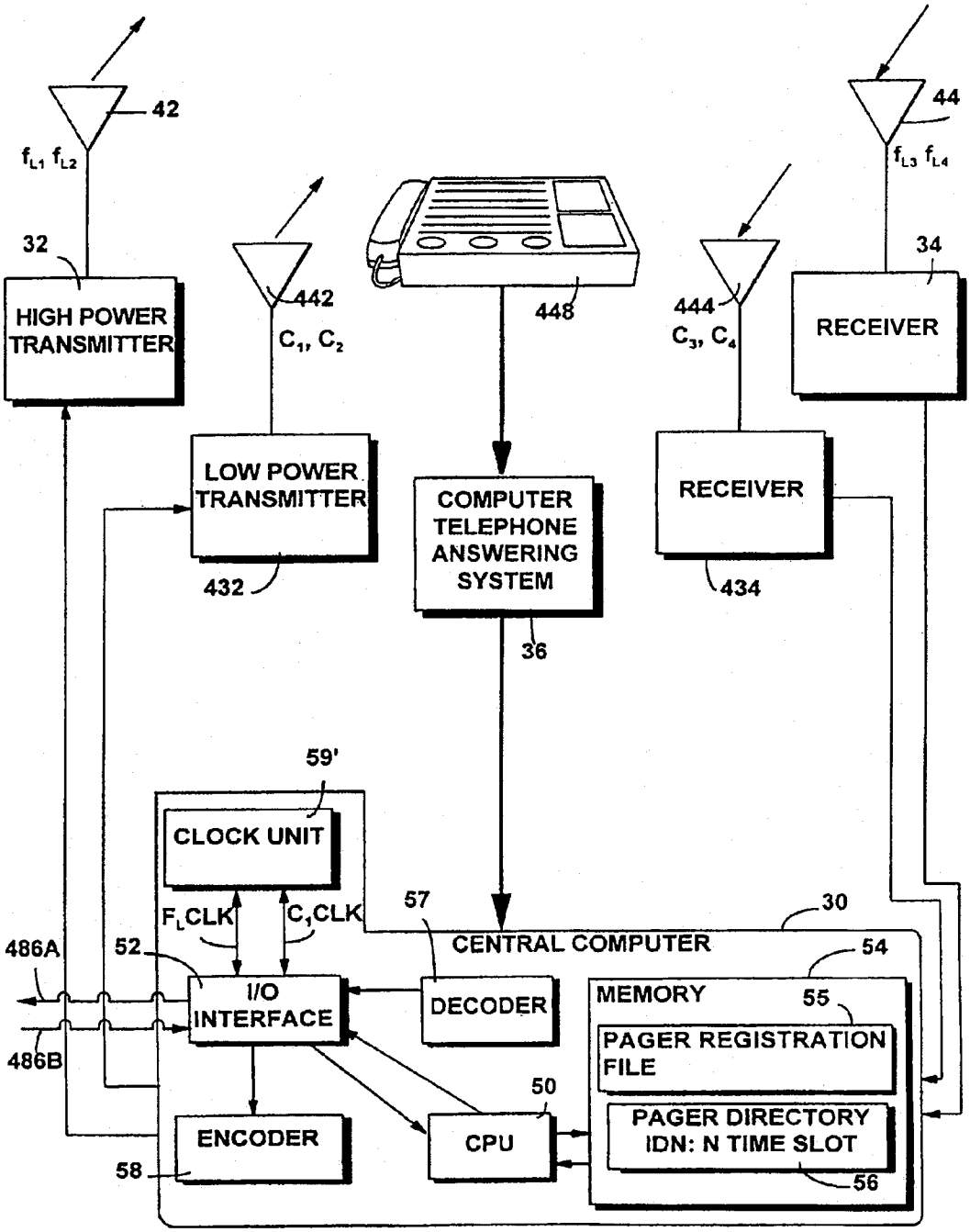


FIG. 8

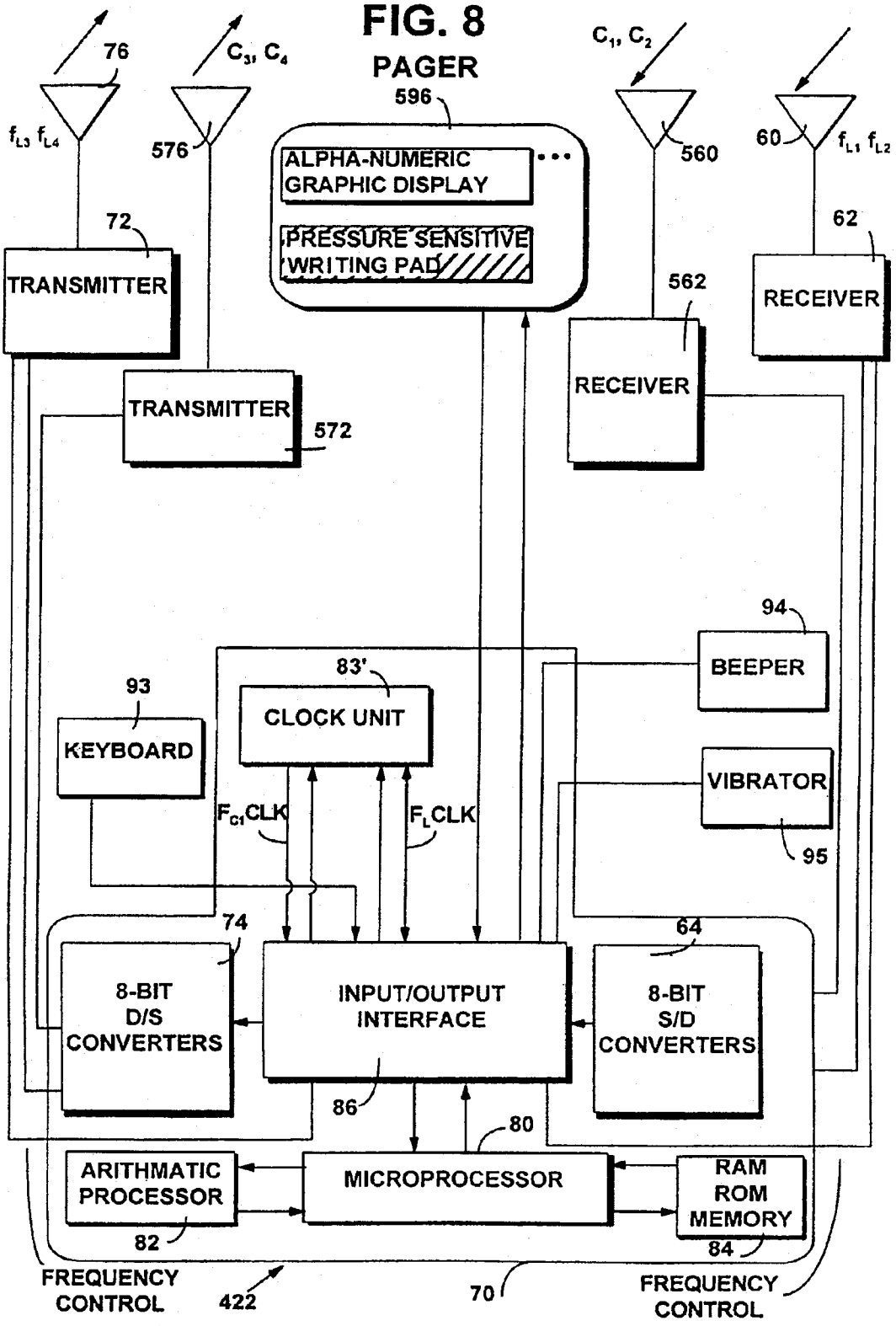
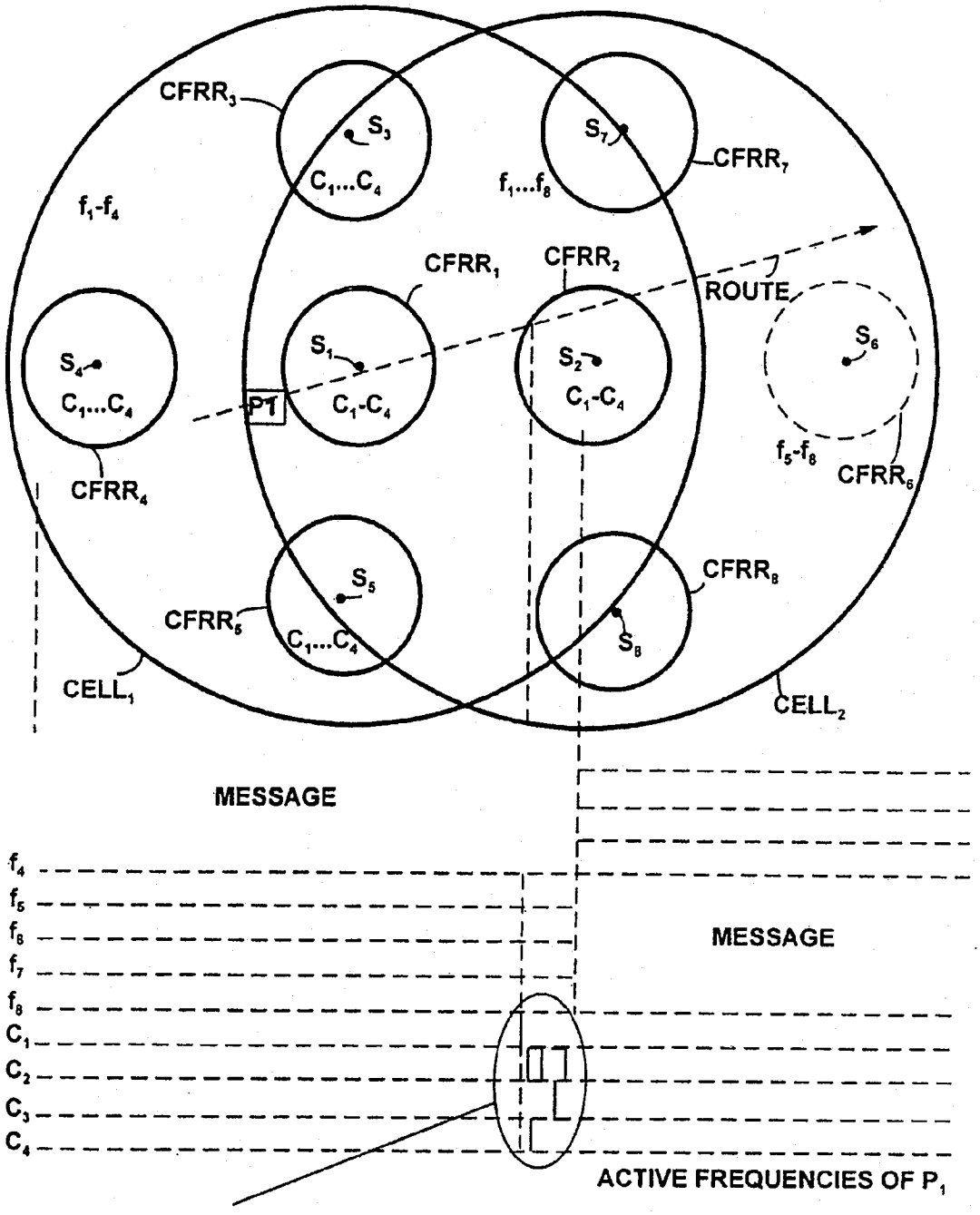

PAGER
596
ALPHA-NUMERIC GRAPHIC DISPLAY
PRESSURE SENSITIVE WRITING PAD
76
f_{L3} f_{L4}
72
TRANSMITTER
C_3, C_4
576
TRANSMITTER
572
C_1, C_2
560
562
RECEIVER
60
f_{L1} f_{L2}
62
RECEIVER
94
BEEPER
83'
CLOCK UNIT
93
KEYBOARD
VIBRATOR
95
F_{C1}CLK
F_LCLK
74
8-BIT D/S CONVERTERS
INPUT/OUTPUT INTERFACE
64
8-BIT S/D CONVERTERS
86
80
ARITHMATIC PROCESSOR
MICROPROCESSOR
RAM ROM MEMORY
82
84
FREQUENCY CONTROL
422
70
FREQUENCY CONTROL

FIG. 9



P1 ALIGN ITS CLOCK WITH S2 FROM C1 (STEP 504)
P1 DETECTED NEW SYSTEM INFORMATION ON C2 (STEP 508)
P1 REQUESTING NEW FREQUENCIES (STEP 510)
S2 TELLS PAGER TO IDENTIFY ITSELF (STEP 616)
P1 SENDS ITS ID INFORMATION ON C3 (STEP 516)
NEW TIME SLOT AND NEW FREQUENCIES
INFORMATION GIVEN ON C2 FROM S2 (STEPS 632 AND 634)

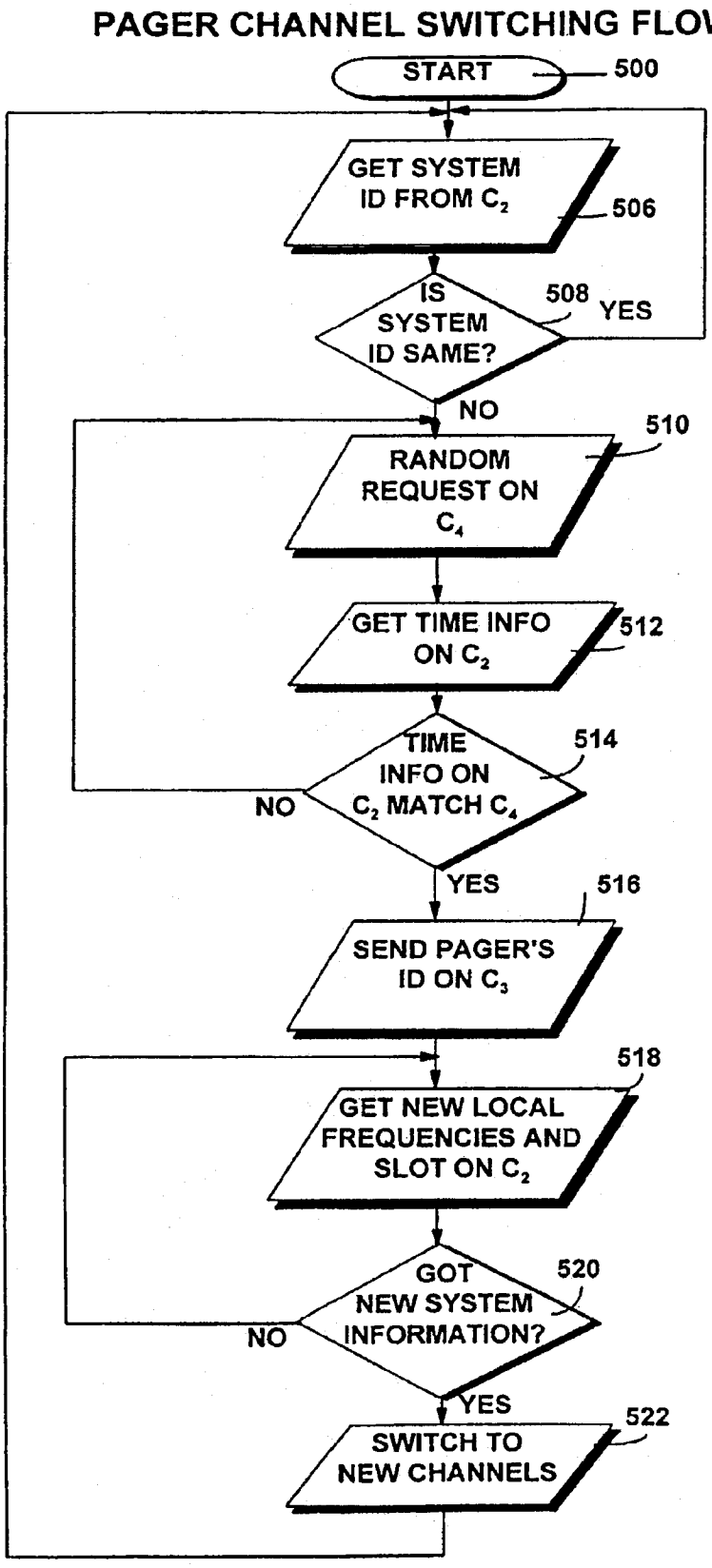
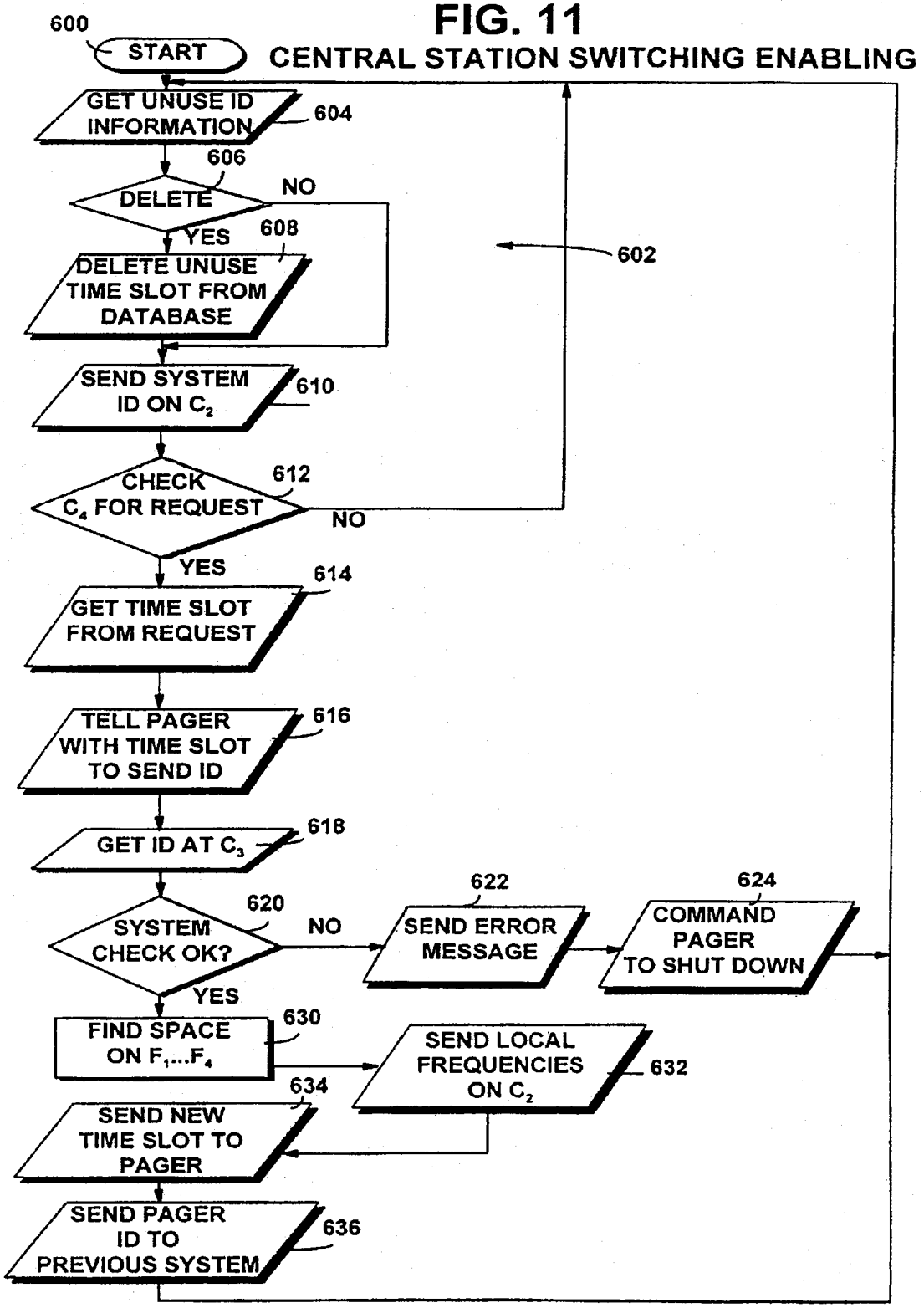

PAGER CHANNEL SWITCHING FLOW CHART
START
500
GET SYSTEM ID FROM C_2
506
IS SYSTEM ID SAME?
508
YES
NO
510
RANDOM REQUEST ON C_4
GET TIME INFO ON C_2
512
TIME INFO ON C_2 MATCH C_4
514
NO
YES
516
SEND PAGER'S ID ON C_3
518
GET NEW LOCAL FREQUENCIES AND SLOT ON C_2
GOT NEW SYSTEM INFORMATION?
520
NO
YES
522
SWITCH TO NEW CHANNELS

FIG. 10

FIG. 11

CENTRAL STATION SWITCHING ENABLING



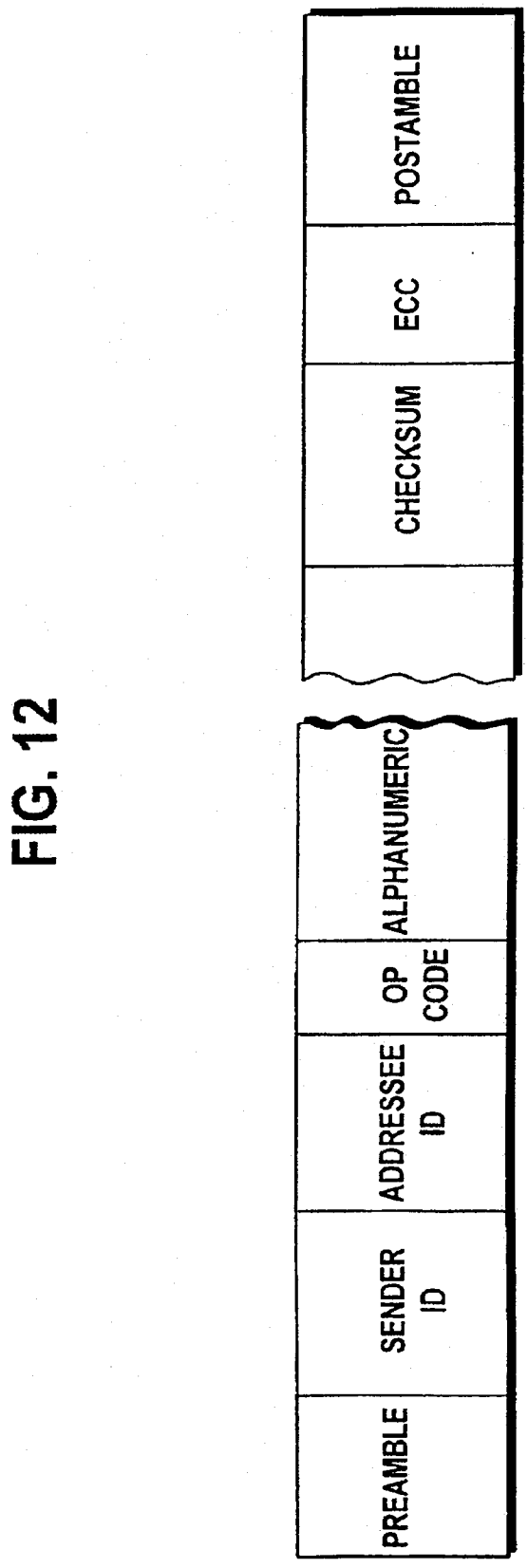
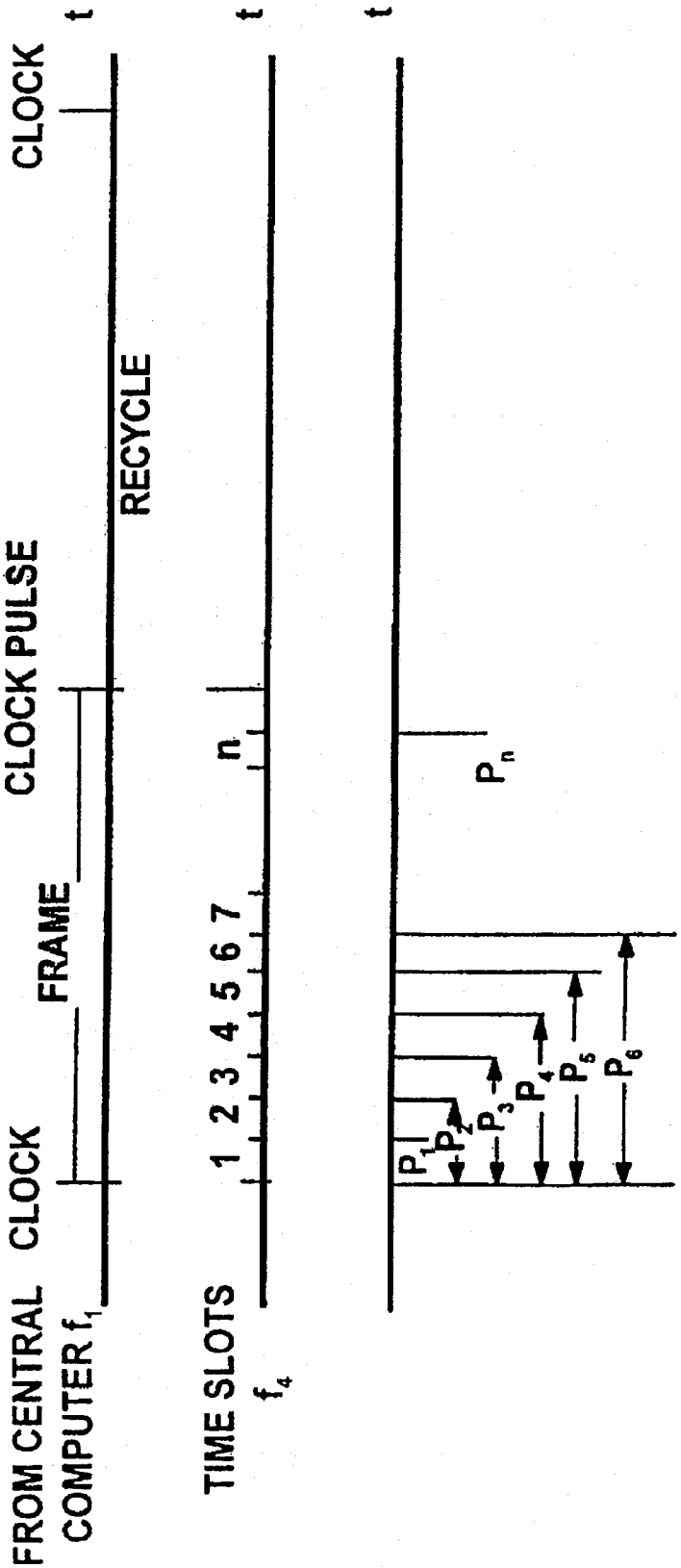

PREAMBLE
SENDER ID
ADDRESSEE ID
OP CODE
ALPHANUMERIC
CHECKSUM
ECC
POSTAMBLE

FIG. 12

FIG. 13


FROM CENTRAL COMPUTER f_1
CLOCK
FRAME
CLOCK PULSE
RECYCLE
t
CLOCK
TIME SLOTS
f_4
1 2 3 4 5 6 7
n
t
t
P_1
P_2
P_3
P_4
P_5
P_6
P_n

NETWORK COMMUNICATION SYSTEM USING A SINGLE RESERVATION REQUEST OVER ONE OR MORE ASSIGNED FREQUENCIES TO IDENTIFY A NODE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 11/350,616 filed on Feb. 8, 2006, which is a continuation of application Ser. No. 09/847,005 filed on May 2, 2001 now U.S. Pat. No. 7,031,716, which is a continuation of application Ser. No. 09/594,662 filed on Jun. 15, 2000 now U.S. Pat. No. 6,282,406, which is a continuation of application Ser. No. 09/259,417 filed on Dec. 9, 1997 now U.S. Pat. No. 6,108,520, which is a continuation of application Ser. No. 08/608,629 filed on Feb. 29, 1996 now U.S. Pat. No. 5,729,827, which is a divisional of 08/264,973, filed Jun. 24, 1994, now U.S. Pat. No. 5,542,115, issued Jul. 30, 1996, entitled "PAGING METHOD AND APPARATUS", naming Wong, et al. as inventors, all of these applications being incorporated by reference herein in their entirety.

BACKGROUND

1. Technical Field

This invention pertains to communications paging, and particularly to two-way paging method and apparatus.

2. Related Art

Over the last several decades, pagers have proven to be important communication devices for contacting remotely situated personnel. Whereas primitive pagers provided primarily only a tonal and/or vibratory output, more modern pagers have enhanced output capabilities such as message-bearing alphanumeric displays.

Paging systems have historically been one-way systems. That is, the user receives a paging message from a central terminal but has no way of responding to that message with the pager. Prior art attempts to provide two-way communication capabilities for a pager have included efforts to connect the pager to a telephone (e.g., to a mobile radio telephone). See, for example, U.S. Pat. No. RE 33,417 to Bhagat et al. (which combines an entire radio pager and radiotelephone linked through an automatic dialer) and U.S. Pat. No. 5,117,449 to Metroka, et. al. (which purports to combine paging and cellular radiotelephone functions in a single unit).

Some pagers have the capability of providing an acknowledgment or response to a paging signal. In some such "ack-back" systems, a user operates a reply input device (e.g., a toggle switch, pushbutton switch, or keyboard) when paged. Typically such ack-back systems involve a complex acknowledgement transmission scheme, involving numerous frequencies or frequency sub-bands. Hand-off of the pager, as the pager travels between differing geographic regions or "cells" served by differing central stations, becomes technically cumbersome when multitudinous frequencies are involved.

SUMMARY

A two-way paging system utilizes four local frequencies for transmissions between pager units and a central control station. A first local frequency carries a local clock; a second local frequency carries communications packets from the central control station to paging units; a third local frequency carries communication packets from the pager units to the central control station; and a fourth local frequency carries a status or request signal from the paging units to the central control station. Transmissions on the fourth local frequency are in accordance with a time divided slot allocation among pager units accessing the central control station.

For a two-way paging system having a plurality of central control stations servicing a corresponding plurality of cells, a total of eight frequencies are utilized within any one cell. Four of the utilized frequencies are the local frequencies, (which may differ from cell to cell), and four of the utilized frequencies are lower power common frequencies or switching frequencies which are used to switch or hand-off a pager unit traveling from one cell to another.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. **1** is a schematic view of a central control station included in a paging system of an embodiment of the invention.

FIG. **2** is a schematic view of a pager unit included in a paging system for use with the central control station of FIG. **1**.

FIG. **3** is a flowchart depicting steps executed by the central control station of FIG. **1**.

FIG. **4** is a flowchart depicting steps executed by the pager unit of FIG. **2** when in a transmit mode.

FIG. **5** is a flowchart depicting steps executed by the pager unit of FIG. **2** when in a receive mode.

FIG. **6** is a timing diagram reflecting communications between the central control station of FIG. **1** and the pager unit of FIG. **2**.

FIG. **7** is a schematic view of a central control station included in a paging system of a second embodiment of the invention.

FIG. **8** is a schematic view of a pager unit included in a paging system for use with the central control station of FIG. **7**.

FIG. **9** is a hybrid schematic view and timing diagram for representing switching operations for the paging system of the second embodiment of the invention.

FIG. **10** is a flowchart depicting steps executed by the pager unit of FIG. **8** in connection with a channel switching operation.

FIG. **11** is a flowchart depicting steps executed by the central control station of FIG. **7** in connection with a channel switching operation.

FIG. **12** is a schematic view of a format of a communications packet utilized with embodiments of the invention.

FIG. **13** is a schematic view illustrating a time divided slot allocation technique according to the invention.

DETAILED DESCRIPTION

FIG. **1** shows a central control station **20** according to a first embodiment of the invention; FIG. **2** shows a paging unit **22** suitable for use with central control station **20**.

As shown in FIG. **1**, central control station **20** includes central computer **30**; transmitter **32**; receiver **34**; and com-

puterized telephone answering system **36**. Transmitter **32** transmits, via transmitting antenna **42**, two local frequencies, namely frequency f_1 and frequency f_2. Receiver **34** is connected to receiver antenna **44** for reception of two local frequencies, namely frequency f_3 and frequency f_4. Computerized telephone answering system **36** is connected to a bank of telephones **48**.

Central computer **30** of central control station **20** comprises a conventional computer equipped with typical components including a CPU **50**; I/O interface **52**; and memory **54**. Although shown only generally in FIG. **1**, it should be understood that memory **54** includes a number of unillustrated memory devices, including (for example) a hard disk drive, RAM, and ROM. FIG. **1** shows that memory **54** has stored therein (among other things) a pager registration file **55** and a pager directory file **56**. Pager files **55** and **56** are typically stored on a hard disk drive of central computer **30**, and upon start-up are loadable into a RAM portion of memory **54**.

Central computer **30** of central control station **20** further includes a decoder **57** (connected between receiver **34** and I/O interface **52** for decoding in-coming communications information from one or more pager units **22**), as well as encoder **58** (connected between I/O interface **52** and transmitter **32** for encoding out-going communications information).

Central control station **20** also includes a clock unit **59** which generates a local clock signal $f_1$clk (which, in turn, is used to modulate frequency f_1).

As illustrated further herein, CPU **50** of central control station **20** prepares communications packets for transmission on frequency f_2. As generally illustrated in FIG. **12**, the communications packets are of a predetermined format, having fields for identification of the central control station, for identification of the addressed pager unit(s) **22**, for an operation code, for (optionally) alphanumeric information, and for other conventional packet-type information such as checksum, error correction, and postamble. The preamble and postamble are specially chosen patterns which can be recognized and distinguished from data for the purpose of determining the beginning and ending of a packet. The alphanumeric information can be in a customary binary 8-bit format. The format of FIG. **12** is illustrative only, as such information as the order of the fields can be varied in other embodiments.

Central control station **20** communicates with a plurality of pager units 22_1, 22_2, . . . 22_N. Only one such pager unit, generically referenced as pager unit **22**, is specifically illustrated and described herein, it being understood that the construction and operation of other pager units may be similar to the one illustration.

As shown in FIG. **2**, pager unit **22** includes a pager receiver antenna **60** which is connected to pager receiver **62**. Pager receiver **62** is, in turn, connected through S/D converter **64** within pager computer **70**. Receiver **62** receives the two local frequencies f_1, and f_2, which frequencies have been modulated to carry in-coming communications information (described in more detail below) to pager computer **70**. On a communications output side, pager computer **70** outputs out-going communications information to pager transmitter **72** via D/S converter **74**. Transmitter **72** broadcasts, on pager antenna **76**, the out-going communications information on the two local frequencies f_3 and f_4.

As also shown in FIG. **2**, pager computer **70** includes pager microprocessor **80** which is connected to each of an arithmetic processor; a memory system **84** (including both ROM and RAM); and I/O interface **86**. I/O interface **86** is connected to a clock unit **87**. I/O interface **86** is also connected to receive in-coming decoded communications information from an 8-bit decoder **88** and to output out-going uncoded communications information to an 8-bit encoder **90**. Decoder **88** is connected to receive in-coming coded communications information from S/D converter **64**; encoder **90** is connected to output out-going coded communications information to D/S converter **74**.

Clock unit **87** is settable by suitable inputs thereto so that clock unit **87** generates a local clock signal $f_1$clk having a frequency corresponding to its input. It should be understood that, in other embodiments, the function of clock unit **87** can be performed at least partially by microprocessor **80** using programmed execution.

I/O interface **86** is also connected to supply an on/off signal on line **92** to pager transmitter **72**, as well as to facilitate input and output with numerous input/output devices. The input/output devices connected to I/O interface **86** include keyboard **93**; beeper **94**; vibrator **95**; and LCD (alphanumeric) display **96**.

Upon manufacture, pager unit **22** is preprogrammed with an identification serial number (e.g., a 7-digit alphanumeric pre-assigned ID number) which is stored in memory **84** (ROM). Pager unit **22** is activated (e.g., at the time of purchase) by inserting a time slot assignment (explained below) both into a predetermined address in memory **84** of pager unit **22** and into pager directory file **56** (stored in memory **54** of central control station **20**).

Operation of First Embodiment

Communication between central control station **20** and pager unit **22** occurs on the four local frequencies, in particular the frequencies f_1, f_2, f_3, and f_4 mentioned above. The first frequency (f_1) carries the local clock-aligning signal from central control station **20** to paging unit **22**. The second frequency (f_2) carries a pager command and alphanumeric data from central control station **20** to paging unit **22**. The third frequency (f_3) carries pager status data and alphanumeric data from paging unit **22** to central control station **20**. The fourth frequency (f_4) carries a pager request signal from paging unit **22** to central control station **20**. In the illustrated embodiment, the frequencies f_1–f_4 are preferably chosen so that $f_1 \neq f_2 \neq f_3 \neq f_4$.

As explained in more detail below and illustrated in FIG. **13**, in normal non-cell-switching operation, the pager request signal on frequency f_4 is transmitted in a predetermined time slot assigned to paging unit **22**. The predetermined time slot on frequency f_4 is related to the clock-aligning signal (carried by frequency f_1) and assigned whereby the fourth frequency is utilizable by a plurality of other paging units. For example, as shown in FIG. **13**, a first time slot on frequency f_4 is assigned to a pager P1; a second time slot is assigned to pager P2, and so on up to time slot n assigned to pager Pn. In the illustrated embodiment, the number of time slots (and accordingly the number of pagers) may be as many as ten thousand or more.

FIG. **3** shows steps executed by CPU **50** of central control station **20** in processing communications to and from one or more paging units. The steps depicted in FIG. **3** are indicative of instructions stored in a ROM portion of memory **54** of central control station **20**.

When central control station **20** is started up (step **100**), an initialization process (step **102**) is conducted. Included in the initialization process is activation of transmitter **32** (so that transmitter **32** can transmit at the two frequencies f_1 and f_2) and activation of receiver **34** (so that receiver **34** can receive the two frequencies f_3 and f_4). Moreover, frequency f, is

modulated to carry the local clock-aligning signal generated by local clock **59**. Then, at step **104**, the pager registration file **55** and the pager directory file **56** are loaded from hard disk into a RAM section of memory **54** (step **104**).

After initialization and loading of the files **55** and **56**, CPU **50** repetitively executes an instruction loop **106**. Loop **106** involves checking to determine (at step **108**) whether a telephone message is being received (via answering system **36** from one of the telephones in bank **48**) and checking to determine (at step **110**) whether a pager message is being received (via transmitter **32** from one of the pager units **22**).

As used herein, a message, whether originated from a telephone or from a pager, may require a plurality of packets for transmission from a central station **20** to a pager **22** or vise versa. In the ensuing discussion, transmission and reception of messages subsumes transmission and reception one or more packets. In general, the packetization of messages will be invisible to the user, meaning that a user enters a message without regard to the number of packets which might be required to transmit the message. The message typically ends with a user-entered message termination character or message delimiter character. The transmitting device (either central station **20** or pager **22**), allocates the message to one or more packets having a format similar to that of FIG. **12**, with the last packet in the message bearing the message termination character. Alternatively, the packets may be formatted in a manner to indicate the number of consecutively related packets emanating from a transmitter (e.g., there may be a separate packet field indicating the continuation number of related packets).

Central computer **30** can distinguish between receipt of a telephone message (at step **108**) and a pager message (at step **110**) by virtue of the fact that I/O interface **52** generates different type of interrupts to CPU **50** depending on the type of message received. If it is determined at step **108** that a telephone message is being received, steps **112**, **114**, and **116** of FIG. **3** are executed.

In processing a received telephone message, at step **112** central computer **30** extracts out-going communications information from the predeterminately sequenced telephone-entered data. The telephone-entered data, entered via a touchpad of a calling one of the telephones in bank **48**, includes by convention an identification (e.g., telephone number) of the calling telephone; an identification of the called pager unit (e.g., the 7-digit alphanumeric pre-assigned ID number); and any character data for transmission followed by a termination character. This out-going communications information is received at central computer **30** in standard DTMF format.

At step **114**, using the ID number of the called pager (obtained at step **112**) central computer **30** checks the pager registration file **55** and directory file **56** to determine whether the called pager unit is registered with central control station **20**. Assuming that the called pager is so registered, at step **114** the central computer **30** also obtains from pager directory file **56** the slot assignment for the called pager unit.

At step **116**, central control station **30** transmits communications information to the called pager unit. In this regard, central control station **20** prepares and transmits (on frequency f_2) a communications message which includes, among other things, the ID of the called pager unit and the character data received from the telephone for transmission of the pager unit **22**. After step **116** is executed, processing returns to loop **106**.

If it is determined at step **110** that a pager message is being received, even numbered steps **132**–**140** of FIG. **3** are executed (prior to returning to loop **106**). As will be seen hereinafter with respect to FIG. **4**, a sending pager unit **22** transmits, in its assigned time slot, a request signal on frequency f_4 when the sending pager unit **22** desires to send a message. As central control station **20** is always monitoring frequency f_4, a request signal carried by frequency f_4 from any pager unit **22** is noted. With reference to the local clock **59**, at step **132** CPU **50** determines in what time slot on frequency f_4 the request signal is detected. Upon detection of the time slot at step **132**, at step **134** CPU **50** consults the pager directory file **56** to determine the identification number of the particular pager unit **22** which originated the request signal.

With the identity of the requesting pager unit **22** now known, at step **136** central control station **20** authorizes the requesting pager unit **22** to transmit its message. In particular, CPU **50** directs preparation of a communications message for transmission on frequency f_2. The particular communications packet prepared at step **136** includes an identification of the requesting pager unit (the addressee of the packet), as well as an operation code ("op" code) which commands/authorizes the requesting pager unit **22** to send its message.

At step **138**, central control station **20** receives a communications message on frequency f_3 sent from the sending (e.g., requesting) pager unit **22**. The communications message prepared and sent by the sending pager unit **22** includes packets of similar format to that shown in FIG. **12**, and includes an identification of a pager to which the message is ultimately addressed as well as its own identification. At step **138**, CPU **50** checks to ensure that the ultimate addressee pager unit is registered in pager files **55** and **56**. At step **140**, CPU **50** makes any necessary reformatting and/or information substitution in the message, and causes the message to be transmitted on frequency f_2. The transmission on frequency f_2 required by step **140** includes the identification of the ultimate addressee (e.g., a pager unit **22**) as well as an operation code indicating that the transmission includes a relayed message from another pager unit.

Steps executed by a pager unit **22** in connection with its transmission mode are depicted in FIG. **4**. Steps executed by a pager unit **22** in connection with its receive mode are depicted in FIG. **5**. The term "mode" as used herein does not connote exclusivity at any particular moment, for it should be remembered that at all times pager unit **22** is receiving transmissions on frequencies f_1 and f_2.

In its transmission mode (see FIG. **4**), after start-up (step **200**) microprocessor **80** of the transmitting pager unit **22** executes a loop **202** wherein user alphanumeric characters (entered via keyboard **93**) are repetitively fetched (at step **204**) until an end of message delimiter is detected (at step **206**). As entered, the characters fetched at step **204** are displayed on LCD display **96**. Entry of the delimiter character at step **206** causes microprocessor **80** to exit loop **202**. By convention, the message must include an addressee ID, which addressee ID is likely the ID of another one of the pager units to which the message entered in step **204** is directed.

After entry of the message awaits entry from keyboard **93** of a transmit command at step **212**. Assuming that the transmit command is entered at step **212**, microprocessor **80** prepares and sends a request signal on frequency f_4. As indicated before, the request signal is transmitted on frequency f_4 in a time slot assigned to the requesting pager unit **22**. It should be kept in mind that pager unit **22** is all the while receiving the local clock-aligning signal on frequency f_1, which enables microprocessor **80** to cause transmission

of the request signal on frequency f_4 at a time corresponding to the specific time slot allotted to the particular sending pager unit **22**.

In the above regard, in accordance with time division techniques, each pager unit 22_1–22_N (e.g., pagers P_1–P_N in FIG. **13**) is assigned a selected one of N number of time slots on frequency f_4.

After transmission of the request signal at step **214**, pager unit **22** awaits receipt of a transmit command from central control station **20**. Preparation and transmission of the transmit command/authorization from central control station **20** is described with reference to FIG. **3**. Upon receipt of the transmit command/authorization from central control station **20** (step **216**), microprocessor **80** prepares (at step **218**) a communications message with one or more packets having a format much like that of FIG. **12**. The addressee ID and alphanumeric field of packets of the communications message is filled with the message entered in loop **202**. At step **220**, the sending pager unit **22** broadcasts the communications packet on frequency f_3.

If a transmit command is not entered at step **212**, or after transmission of the message at step **220**, microprocessor **80** awaits entry of at least one of several possible special function keys at step **222**. For example, the user may press a function key which requires storage of the message (whether yet transmitted or not) [see step **228**]. Alternatively, the user may press function keys which facilitate editing or erasure of the message (see steps **224** and **226**, respectively). To complete the message and begin work on another message, a special function key for an exit operation (step **230**) must be pressed.

FIG. **5** depicts steps executed by microprocessor **80** of pager unit **22** when in a receive mode. After start-up (step **302**), and as indicated by step **304**, pager unit **22** receives transmissions from central control station **20** on frequency f_2. Once a complete packet is received (determined at step **306**), a check is made (at step **308**) whether the addressee ID in the communications packet (see packet format of FIG. **12**) is the ID of the receiving pager unit **22**. If the determinations of either step **306** or **308** are negative, pager unit **22** awaits either completion of the communications packet (in the case of step **306**) or receipt of another communications packet (in the case of step **308**) by looping back to step **304**.

Assuming that the received communications packet is designated for this particular receiving pager unit **22**, at step **310** microprocessor **80** consults the operation code field of the communications packet (see FIG. **12**) to determine if the operation code indicates that the message includes a command. If the operation code indicates a command, a command processing routine (framed by broken lines **312** in FIG. **5**) is executed.

Assuming for the moment that the operation code does not indicate a command, at step **314** microprocessor **80** of pager unit **22** stores the alphanumeric field portion of the communications packet (which at least partially forms the message) in a RAM portion of memory **84**. Since a message communicated from central processing station **20** may require several communications packets for completion of the message (with subsequent communication packets providing continuations of the message content), microprocessor **80** checks at step **316** to ensure that the entire message has been received. If not, processing continues back at step **304** for reception of a further communications packet.

Upon reception of an entire communications message, at step **318** microprocessor **80** determines whether pager unit **22** is in a beep mode or a vibrate mode. In this regard, there are numerous ways of setting paging unit **22** to the desired mode, either by a specially dedicated switch on paging unit **22** or by data entry using keyboard **93**. If pager unit **22** is in a beep mode, microprocessor **80** outputs a signal which causes I/O interface **86** to issue a further signal to activate beeper **94** (step **320**). Alternatively, if pager unit **22** is in a vibrate mode, microprocessor **80** outputs a signal which causes I/O interface **86** to issue a further signal to activate vibrator **95** (step **322**).

At step **324**, microprocessor **80** directs I/O interface **86** to send the alphanumeric message data to LCD display **96**, so that the received message can be viewed by the user.

After notification to the user (either via beeper **94** and/or vibrator **95**), and display (on LCD **96**) of the received alphanumeric data, microprocessor **80** returns to step **304** to check whether further communications packets are being received.

The command processing routine (framed by broken lines **312** in FIG. **5**) first determines (step **330**) which particular operation is being commanded. This determination is based on the content of the operation code, which is different for different command types. If the operation code indicates an error shut-down, execution jumps to an error shut-down sub-routine which begins at step **340**. If the operation code indicates a time slot change, execution jumps to a change time slot sub-routine which begins at step **350**. If the operation code requires transmitter shut-down, execution jumps to a transmitter shut-down sub-routine which begins at step **360**. If the operation code requires transmitter re-enablement, execution jumps to a transmitter reenable sub-routine which begins at step **370**. If the operation code requires clock re-set, execution jumps to a clock re-set sub routine which begins at step **380**.

In connection with the error shut down sub-routine, at step **342** microprocessor **80** obtains an indication of error type from the communications packet. The error type is stored in memory **84** (step **344**) and then displayed on LCD display **96** (step **346**). Then microprocessor **80** issues a command (at step **348**) to shut down pager unit **22**, which shut-down occurs at step **349**.

In connection with the time slot changing sub-routine, at step **352** microprocessor **80** extracts, from the received communications packet, information indicative of the new time slot assigned to the receiving pager unit **22**. The new time slot is entered (at step **354**) into memory **84** and thereafter utilized (until further change) in connection with transmission of request signals on frequency f_4 (see, for example, step **214** of FIG. **4**).

The time slot changing sub-routine may also include other operations, if desired, including (for example) eliminating unused time slots (thereby increasing scanning rate); diagnosing and trouble shooting; and avoiding interruption of service from malfunctioning or ill-functioning equipment.

In connection with the transmitter shut down sub-routine, at step **362** microprocessor **80** directs I/O interface **86** to issue an OFF command to transmitter **72**. In connection with the transmitter re-enable sub-routine, at step **372** microprocessor **80** directs I/O interface **86** to issue an ON command to transmitter **72**.

In connection with the clock re-set sub-routine, at step **382** microprocessor **80** directs that clock **59** of pager unit **22** be set.

After execution of steps **354**, **362**, **372**, or **382**, execution continues back to step **304** for processing of potential further communications packets. Thus, unless an error shut-down is noted, each entry of the command processing routine (framed by broken lines **312** in FIG. **5**) is followed by a loop back to step **304**.

FIG. **6** is a timing diagram showing the frequencies f_1–f_4 and integration of the steps depicted in FIGS. **3**–**5**, particularly in the context of a request by a sending pager unit **P1** for sending a message to a sendee pager unit **P2**. As employed in FIG. **6**, "computer" refers to central control station **20**. It should be understood that the sending pager unit **P1** and the sendee pager unit **P2** operate in both the transmission mode as depicted in FIG. **4** and in the receiver mode as depicted in FIG. **5**. In general, FIG. **6** shows transmission of a message from pager unit **P1** (via central control station **20**) to pager unit **P2**; transmission of a confirmation message from pager unit **P2** (via central control station **20**) to pager unit **P1**; and transmission of a message from pager unit **P1** to central control station **20** indicating that pager unit **P1** received the confirmation message from pager unit **P2**.

Structure of Second Embodiment

FIG. **7** shows a central control station **420** according to a second embodiment of the invention; FIG. **8** shows a paging unit **422** suitable for use with central control station **420**.

FIG. **9** shows a wide area paging system including a plurality of central control stations **S1**–**S8** (each identical to central control station **420**), each preferably geographically centered within a respective cell. Each central control station **S1**–**S8** broadcasts its own local frequencies, as well as a set of common or switching frequencies C_1–C_4. The common frequencies C_1–C_4 are broadcast at a lower power, so that reception thereof occurs only in a relatively small neighborhood or common frequency reception region (CFRR) [also referred to as a "switching region"] about the central control station. The local frequencies are broadcast at a significantly greater power for reception substantially throughout the cell. For example, in FIG. **9**, central control station **S1** broadcasts its lower power common frequencies C_1–C_4 to $CFRR_1$ and its higher power local frequencies f_1–f_4 to CELL; central control station **S2** broadcasts its lower power common frequencies C_1–C_4 to $CFRR_2$ and its higher power local frequencies f_5–f_8 to $CELL_2$.

As also shown in FIG. **9**, $CELL_1$ and $CELL_2$ overlap in an overlap region shown in FIG. **9**. Station **S1** utilizes a set of local frequencies f_1–f_4; station **S2** utilizes a different set of local frequencies f_5–f_8. Both stations **S1** and **S2** utilize the same set of common or switching frequencies C_1–C_4. Thus, each central control station utilizes two sets of frequencies, there being four frequencies in each set, resulting in a total of eight frequencies handled per station.

Thus, the second embodiment of the invention is suitable for a system having a plurality of central control stations $\mathbf{420}_x$ where x=1,2, . . . M. Each central control station $\mathbf{420}_x$ transmits and receives a set of local frequencies f_{L1}, f_{L2}, f_{L3}, f_{L4} in an associated geographical area or cell, as well as the set of common or switch frequencies C_1, C_2, C_3, C_4. While the values of the local frequencies f_{L1}, f_{L2}, f_{L3}, f_{L4}, vary from cell to cell (e.g., differ for differing central control stations $\mathbf{420}_x$), the values of the common or switch frequencies C_1, C_2, C_3, C_4 are uniform through the system (e.g., for all central control stations $\mathbf{420}_x$).

Although not shown in FIG. **9**, it should be understood that the pattern of central control stations repeats in like manner in all compass directions in accordance with the prescribed geographical boundaries of the paging system. Moreover, although not specifically illustrated in FIG. **9**, it should also be understood that each central control station **420** has an associated CFRR.

The common or switching frequencies C_1–C_4 have an analogous function to the corresponding local frequencies f_1–f_4, respectively. In this regard, frequency C_1 carries a clock frequency transmitted by central control station(s), although the clock rate on common frequency C_1 preferably varies among central control stations. Frequency C_2 is used to transmit information from central control station(s) to pager unit(s); frequency C_3 is used to transmit information from a pager unit to a central control station; frequency C_4 is used by pager units to issue a request signal. Frequency C_2 carries packets having a format similar to that of FIG. **12**. In analogous manner to frequency f_2, the packets carried by frequency C_2 may have command codes. Among the C_2 command codes are a SYSTEM COMMAND CODE; a LOCAL FREQUENCY DOWNLOAD COMMAND CODE; a SLOT RECOGNITION COMMAND CODE; and a SLOT ASSIGNMENT COMMAND CODE.

As shown in FIG. **7**, central control station **420** resembles central control station **20** of the embodiment of FIG. **1** (similar components being assigned the same reference numerals for simplicity). However, central control station **420** is augmented by inclusion of a further transmitter, known as common frequency transmitter **432**, together with its common frequency transmission antenna **442**, for transmitting the common frequencies C_1 and C_2. In contrast to the high power transmitter **32**, transmitter **432** is a low power transmitter. Further, central control station **420** is augmented by inclusion of a further receiver, known as the common frequency receiver **434**, together with its common frequency receiver antenna **444**, for reception of the common frequencies C_3 and C_4.

Central control station **420** of FIG. **7** includes a clock unit **59'** which generates two clocking signals—a first or local clocking signal $f_L$clk and a second or common clocking signal C_1clk. The local clocking signal $f_L$clk is used to modulate frequency f_1); the common clocking signal is used to modulate the common frequency C_1.

The central computers **30** of the central control stations **420** are serially connected to one another by an output line **486**A and an input line **486**B. In particular, although not expressly shown as such in FIG. **7**, computer **30** of FIG. **7** (like that of FIG. **1**) includes an I/O interface to which the serial lines **486**A and **486**B are connected. Serial lines **486**A and **486**B are used, for example, to update contents of the pager registration file **55** and the pager directory file **56**.

As shown in FIG. **8**, pager unit **422** resembles pager unit **22** of the embodiment of FIG. **2** (similar components again being assigned the same reference numerals for simplicity). However, pager unit **422** (in like manner as central control station **420**) is augmented by inclusion of a further transmitter, known as common frequency transmitter **572**, together with its common frequency transmission antenna **576**, for transmitting the common frequencies C_3 and C_4. Further, central control station **420** is augmented by inclusion of a further receiver, known as the common frequency receiver **434**, together with its common frequency receiver antenna **444**, for reception of the common frequencies C_1 and C_2.

The operational frequencies of transmitter **72** and receiver **62** are changeable in accordance with values transmitted on "frequency control" lines from computer **70**. In particular, the frequency control lines are connected to I/O interface **86** in computer **70**. As described in more detail below, when a pager unit **422** migrates into a new CFRR, signals are applied on the frequency control lines in order to switch pager unit **422** from the local frequencies of an old cell to the local frequencies of a new cell associated with the new CFRR into which pager unit **422** migrates.

Pager **422** includes a clock unit **83'** which is capable of separately generating local clocking signals $f_L$clk and the common clocking signals f_{c1}clk for use by microprocessor **80**. These clocking signals are initiated and their frequencies set by appropriate respective inputs to clock unit **83'**.

FIG. **8** also shows that pager unit **422** has data I/O unit **596** which includes both an alphanumeric graphic display and a pressure sensitive writing pad. The alphanumeric graphic display is a dot matrix device which can display characters and graphics. The writing pad has a 16×48 dot area.

Operation of Second Embodiment

As shown in FIG. **9**, a pager unit P1 is assumed to have been operating in $CELL_1$ and to have previously received the common frequencies C_1–C_4 and local frequencies f_1–f_2 from station S1. Now pager unit P1 travels on a route indicated by broken arrow-headed line ROUTE. In traveling along the ROUTE, pager unit P1 continues to operate on local frequencies f_1–f_2, even as it travels through the cellular overlap region. However, when page unit P1 enters a new common frequency reception region (i.e., $CFRR_2$), a switching or hand-off operation occurs. In the switching operation, as explained in more detail below, pager unit P1 obtains common frequencies C_1–C_4 from central control station S2 and, as a result, can switch from the local frequencies f_1–f_4 of $CELL_1$ to the local frequencies f_5–f_8 of $CELL_2$. In order to effect the switching or hand-off operation, pager unit P1 executes a channel switching routine; the central control station S2 executes a switching enabling routine.

In connection with the channel switching routine and the switching enabling routine, when pager unit P1 moves into $CFRR_2$, pager unit P1 will receive the clocking signal on frequency C_1 from station S2. At such point, pager unit P1 will automatically align its clock unit with the clocking signal from station S2.

Referring now to the channel switching routine executed by pager P1 subsequent to start-up (step **500**), at step **506** pager unit P1 obtains information characterizing the system centered about station S2. Such characterizing information is referred to as system identification or system ID information.

At step **508**, microprocessor **80** of pager unit P1 checks to determine if there is any new system ID information acquired on frequency C_2. That is, microprocessor **80** checks to determine if system ID information is received on frequency C_2 (which can occur only in a CFRR) and, if so, compares the system ID information to the immediately previously-stored system ID information. If the previous and most recently-acquired system IDs are the same, pager unit P1 realizes that it is still in the jurisdiction of the same station (e.g., station S1). If not, pager unit P1 realizes that it has now wandered into a CFRR of a new station (e.g., station S2) and, at step **510**, initiates a request on frequency C_4 for communication with the central control station (e.g., station S2) for $CELL_2$.

In the above regard, since pager unit P1 has not yet been assigned a time slot for $CELL_2$, the request on frequency C_4 is randomly made. However, pager unit P1 keeps track of the time slot in which it makes its request to the new central control station (e.g., station S2).

Thereafter, pager unit P1 continues to monitor (step **512**) communications packets from station S2 on frequency C_2, waiting for station S2 to issue a message which references the time slot at which pager unit P1 made its request of step **510**. In particular, page unit P1 awaits a message from station S2 on frequency C_2 that includes both a SLOT RECOGNITION COMMAND CODE and information stored in the same time slot which pager unit P1 randomly generated. Since the message including the SLOT RECOGNITION COMMAND CODE includes station S2 as the sender and mirrors the slot randomly generated by pager unit P1, pager unit P1 recognizes the message as being addressed to pager unit P1 and considers issuance of such a message by station S2 (see step **612** of FIG. **11**) to constitute authority for pager unit P1 to communicate further with station S2. In this regard, at step **514** microprocessor **80** of pager unit P1 determines if there is a match between the time slot of a received message and the time slot at which the random request was made at step **510**.

Assuming a match is eventually found at step **514**, at step **516** pager unit P1 sends a communications packet on frequency C_3 to station S2, with the communications packet including the identification or ID of pager unit P1. Using pager registration file **55**, station S2 verifies that the ID of pager unit P1 is a valid ID, and thereafter sends (on frequency C_2) to pager unit P1 a message with the command code LOCAL FREQUENCY DOWNLOAD, which message informs pager unit P1 of the values of the local frequencies handled by station S2 (e.g., frequencies f_5–f_8). Thereafter, as also reflected by step **518**, station S2 sends (on frequency C_2) to pager unit P1 a message with the command code SLOT ASSIGNMENT COMMAND CODE, which message informs pager unit P1 of its slot assignment on frequency f_8. Microprocessor **80** then changes its slot allocation by steps which are similar to those discussed with the afore-mentioned change time slot routine (see steps **350**, **352**, and **354** of FIG. **5**). Step **518** of FIG. **10** reflects reception of the local frequency values and reception of the slot assignment.

After acquisition of all local frequencies and the slot assignment is completed (step **520**), microprocessor **80** implements (at step **522**) a switch to the new local frequencies (e.g., frequencies f_5–f_8). In this regard, microprocessor **80** instructs I/O interface **86** to change transmitter **72** from frequencies f_3, f_4 to frequencies f_7, f_8; and to change receiver **62** from frequencies f_1, f_2 to frequencies f_5, f_6. I/O interface **86** accomplishes the frequency changes by applying appropriate values on the frequency control lines connecting the I/O interface to transmitter **72** and receiver **62**, respectively.

After the switch to new local frequencies at step **522**, microprocessor **80** loops back to step **506**, ultimately to determine when any further switching may be required.

Steps involved in the switching enabling routine executed by a central control station (e.g., station S2) are depicted in FIG. **11**. After start-up (step **600**), CPU **50** determines executes a loop **602** which enables CPU **50** to clean up its pager directory file **56** and to check if any new pager units have wandered into the cell which it administers.

In particular, at step **604** CPU determines whether its central control station (e.g., S2) has been advised by any other central control station (e.g., S3) that a pager unit, formerly under the control of its central control station (e.g., S2), has come under the control of the other central control station (e.g, S3). Such advisement occurs on the serial links connecting the central control stations 420_x, and particularly input serial link **486**B. If such advisement occurs, the ID for the wandered-away pager is deleted from the pager directory file **56** for station S2 (as reflected by steps **606** and **608**).

At step **610**, CPU **50** causes messages with a SYSTEM COMMAND CODE to be transmitted on frequency C_2. As indicated before, messages transmitted on frequency C_2 include a packet(s) having a format such as that shown in

FIG. **12**. The message with the SYSTEM COMMAND CODE particularly includes the central station ID number in its alphanumeric data field.

At step **612**, central control station **420** checks to determine if a request signal has been transmitted by any pager unit **422** on frequency C_4 (as occurred, for example, in context of the discussion of FIG. **10**, particularly step **510**). Such a request signal would likely be issued from a pager unit **422** which has just wandered into the CFRR controlled by the central control station (e.g., into $CFRR_2$ controlled by station S**2**). If no such request signal is detected, loop **602** is again repeated.

In the event that a request signal is detected at step **612**, central control station **420** notes specifically the time slot on frequency C_4 at which the request occurred (step **614**). At this point, such time slot is the only way central control station **420** can identify the in-wandering pager unit **422**. Central control station **420** desires for the in-wandering pager unit **422** to transmit its identification (ID), but cannot specifically address the in-wandering pager other than with reference to the detected time slot. Accordingly, at step **616**, central control station **420** prepares and transmits a message on frequency C_2 which has a SLOT RECOGNITION COMMAND CODE. The message including the SLOT RECOGNITION COMMAND CODE includes station S**2** as the sender and mirrors the slot randomly generated by pager unit P**1** (e.g, the time slot at which the in-wandering pager unit **422** issued its request). This transmission on frequency C_2 constitutes authority for pager unit P**1** to transmit its identification.

Step **618** denotes acquisition by central control station **420** of the identification (ID) of the in-wandering pager unit **422**. At step **620**, central control station **420** checks its pager registration file **55** to determine if the pager ID is a valid ID. If not, an error message is generated and transmitted (at step **622**), followed by a command for pager unit P**1** to shut down (see step **624**).

Assuming that the identification of pager unit **422** was validated at step **620**, CPU **50** checks (at step **630**) its pager directory file **56** to locate an available time slot for the in wandering pager unit **422**, and then associates the available time slot with the ID of the in-wandering pager unit **422**. Then, at step **632**, using a message on frequency C_2 with a LOCAL FREQUENCY DOWNLOAD COMMAND CODE, central control station **420** sends the values of its local frequencies (e.g., f_5, f_6, f_7, f_8) to the in-wandering pager unit **422**. The central control station then (at step **634**) assigns to the in-wandering pager unit **422** a new time slot on its local frequencies using a message on frequency C_2 with a SLOT ASSIGNMENT COMMAND CODE. Processing of the change time slot command by the in-wandering pager unit **422** is understood with analogous reference to FIG. **5**, particularly steps **350**, **352**, and **354**.

Upon completion of step **634**, the in-wandering pager unit **422** is fully initiated into its new cell (e.g., $CELL_2$), and has left the jurisdiction of its former control station (e.g, $CELL_1$ and station S**1**). Accordingly, at step **636**, CPU **50** requests its I/O interface to issue a command on serial line **486**A which advises (using pager ID) that the in-wandering pager **422** is now under its jurisdiction, so that former jurisdictions (e.g., S**1**) can delete this pager unit from their pager directory files **56**. Such deletion is understood with reference to steps **604**–**608** as above-described.

In addition to illustrating geographical location of pager P**1**, stations S**1** and S**2**, and cells $CELL_1$ and $CELL_2$, FIG. **9** shows the relative timing of communications occurring on common frequencies C_1–C_4. FIG. **9** specifically relates the timing of communications transmissions to specific ones of the aforedescribed steps executed by central control station **420** (the switching enabling routine of FIG. **11**) and by pager unit **422** (the channel switching routine of FIG. **10**).

Although the central control stations 420_x use the same common frequencies C_1–C_4, there is no interference or confusion of these signals transmitted from the control stations 420_x. The common frequencies C_1–C_4 are broadcast at a relatively lower power than the local frequencies f_1–f_4 so that reception of the common frequencies C_1–C_4 occurs only in a limited neighborhood (CFRR) about the central control station 420_x. Accordingly, pager units **422** traveling through the system receive common frequencies C_1–C_4 only in the limited and non-overlapping CFRRs.

System operational characteristics, such as cell diameter, CFRR diameter, power level of the local frequencies (e.g., f_1–f_4), and power level of the common frequencies (C_1–C_4) can be field adjusted to suit numerous factors, including particularly the terrain and topography of the geographical region covered by the system. By way of non-limiting example, in one embodiment, the radius of each cell is on the order of about 20 miles; while the radius of each CFRR is on the order of about 10 miles or less. In the same example, the power for transmission of the local frequencies can be in a range of from about 3 watts to 1000 watts; while the power for transmission of the common frequencies C_1–C_4 is preferably less than 2 watts.

Thus, the invention provides a two-way paging system which operates independently from a telephone system for wireless data communication between users. The invention minimizes use of available frequencies allowed by the Federal Communications Commission (FCC), using only four local frequencies f_1–f_4 for any given cell and (for expanded, multi-cellular coverage) only four common or switching frequencies C_1–C_4. In order to minimize the number of frequencies (e.g, channels) utilized, techniques of time division sharing and synchronization are employed. A transmission power differential between the local frequencies and the common frequencies is also employed. These techniques allow data transmission to be kept separate from different pagers and thus eliminates merging of data.

The switching technique of the present invention provides extended geographical coverage and minimizes paging time by increasing the number of frequencies utilized in a cell from four (e.g, the four local frequencies) to eight (the four local frequencies plus the four common frequencies).

In connection with verification of pager ID, it should be understood that a single pager registration file might be stored in a memory file only one of a plurality of central control stations, and that in such case verification would constitute issuing a search command (on the serial links **486**) to locate a pager ID in the one (remote) memory file, with the results of the search being reported back to the inquiring central control station.

The keyboards illustrated herein can, in some embodiments, be multi-language keyboards or writing pads which permit typing of English, Chinese, or Japanese languages, for example. The writing pad is especially useful in countries such as Japan, Thailand, the middle East or China where English-like alphabets are not used. The writing pad could also be used to sketch and transmit graphics. Moreover, data compression/de-compression techniques can be utilized in connection with data transfer.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various alterations in form and detail may be made therein

without departing from the spirit and scope of the invention. For example, it should be understood that repeaters may be employed within cells to facilitate transmission when a pager unit ventures far from a central control station.

What is claimed is:

1. A method of communicating data comprising:

receiving a first signal transmitted from a communication controller at a first node, said first signal including information allowing the first node to transmit a request signal to the communication controller;

transmitting the request signal from the first node to the communication controller, said request signal transmitted from the first node to the communication controller in response to the first node receiving the first signal;

receiving a second signal transmitted from the communication controller to the first node, said second signal from the communication controller being transmitted in response to the communication controller receiving the request signal from the first node, said second signal granting the first node permission to transmit data to the communication controller; and

transmitting the data from the first node to the communication controller,

wherein the communication controller transmits to the first node information relating to at least one frequency wherein the first node communicates with the communication controller.

2. The method of claim 1, wherein the at least one frequency used for transmission between the communication controller and the first node is timeslotted.

3. The method of claim 2, wherein the communication controller transmits said first signal to the first node in at least one timeslot within the at least one frequency.

4. The method of claim 2, wherein said second signal transmitted to the first node includes information relating to at least one timeslot within the at least one frequency wherein to the first node transmits said data.

5. The method of claim 4, wherein said at least one timeslot within at least one frequency allocated to the first node for transmitting said data is at least one timeslot within at least one data transmission frequency allocated to the first node for transmitting said data.

6. The method of claim 4, wherein the communication controller maintains radio resources allocated to the first node for sending transmissions to the communication controller, wherein said radio resources comprise the at least one timeslot assigned to the first node for the first node to further communicate with the communication controller, wherein the communication controller may remove the at least one timeslot assigned to the first node when the at least one timeslot assigned to the first node is unused by the first node for a predetermined period of time.

7. The method of claim 5, wherein the at least one timeslot within the at least one data transmission frequency allocated by the communication controller to the first node in the second signal is assigned exclusively to the first node.

8. The method of claim 5, wherein the data transmitted from the first node to the communication controller is transmitted on at least one dedicated channel, wherein said at least one dedicated channel is at least one timeslot within the at least one data transmission frequency assigned exclusively to a node for transmitting data to the communication controller.

9. The method of claim 7, wherein the at least one timeslot assigned to the first node are varied.

10. The method of claim 2, wherein the first node receives information from the communication controller assigning a new timeslot for transmitting.

11. The method of claim 2, wherein the first node randomly chooses at least one timeslot wherein the first node transmits.

12. The method of claim 1, wherein said first signal to the first node is transmitted within the at least one frequency.

13. The method of claim 1, wherein said first signal transmitted from the communication controller to the first node is transmitted within at least one predetermined frequency.

14. The method of claim 1, wherein said information relating to at least one frequency wherein the first node communicates with the communication controller comprises information relating to at least one frequency wherein the first node may transmit a request signal.

15. The method of claim 14, wherein said information relating to at least one frequency wherein the first node communicates with the communication controller is transmitted from the communication controller to the first node prior to the first node transmitting said request signal.

16. The method of claim 14, wherein said information allowing the first node to transmit a request signal to the communication controller comprises information relating to at least one timeslot within the at least one frequency wherein the first node may transmit said request signal.

17. The method of claim 16, wherein said request signal from the first node is transmitted within the at least one timeslot within said at least one frequency wherein the first node may transmit said request signal.

18. The method of claim 17, wherein the at least one timeslot in which the first node may transmit the request signal is one of a series of timeslots where the network codes can transmit requests, the series of timeslots occurring repeatedly after transmission of the first signal from the communication controller and continuing after receipt of the request signal transmitted to the communication controller.

19. The method of claim 17, wherein the at least one timeslot within the at least one frequency allocated by the communication controller to the first node in the first signal is assigned exclusively to the first node.

20. The method of claim 18, wherein the series of timeslots where the network nodes can transmit requests occurs repeatedly without being disabled during operation of the communication controller.

21. The method of claim 16, wherein the communication controller maintains radio resources allocated to the first node for sending transmissions to the communication controller, wherein said radio resources comprise the at least one timeslot assigned to the first node for the first node to further communicate with the communication controller, wherein the communication controller may remove the at least one timeslot assigned to the first node when the at least one timeslot assigned to the first node is unused by the first node for a predetermined period of time.

22. The method of claim 1, wherein said information allowing the first node to transmit a request signal to the communication controller comprises information relating to a set of frequencies wherein the first node transmits and receives information from the communication controller, and

wherein at least one frequency from the set of frequencies is allocated to the first node for transmitting the request signal from the first node to the communication controller.

23. The method of claim 1, wherein said information allowing the first node to transmit a request signal to the communication controller comprises information relating to at least one timeslot wherein the first node may transmit a first request signal from the first node.

24. The method of claim 23, wherein said request signal transmitted from the first node is transmitted within the at least one timeslot identified in the first signal from the communication controller.

25. The method of claim 23, wherein the at least one timeslot is assigned to the first node by the communication controller.

26. The method of claim 1, wherein said request signal from the first node is transmitted within at least one predetermined frequency.

27. The method of claim 1, wherein said request signal transmitted from the first node to the communication controller is transmitted within at least one predetermined frequency.

28. The method of claim 1, wherein said request signal from the first node includes a request for transmitting a specified amount of data from the first node to the communication controller.

29. The method of claim 1, wherein the communication controller transmits said second signal to the first node within the at least one frequency.

30. The method of claim 1, wherein said second signal transmitted from the communication controller to the first node is transmitted within at least one timeslot.

31. The method of claim 28, wherein said second signal transmitted from the communication controller is transmitted within at least one timeslot within the at least one frequency.

32. The method of claim 1, wherein said second signal transmitted from the communication controller to the first node is transmitted within at least one predetermined frequency.

33. The method of claim 1, wherein said second signal transmitted from the communication controller to the first node is transmitted within at least one timeslot within at least one predetermined frequency.

34. The method of claim 1, wherein said information relating to at least one frequency wherein the first node communicates with the communication controller comprises information relating to at least one frequency allocated to the first node for transmitting data.

35. The method of claim 34, wherein said at least one frequency allocated to the first node for transmitting data is transmitted from the communication controller to the first node prior to the first node transmitting the data.

36. The method of claim 34, wherein said at least one frequency allocated to the first node for transmitting data is transmitted from the communication controller to the first node after the first node has transmitted the request signal.

37. The method of claim 34, wherein said at least one frequency allocated to the first node for transmitting data is transmitting from the communication controller to the first node while the first node is in the process of transmitting data.

38. The method of claim 34, wherein said at least frequency allocated to the first node for transmitting data is at least one data transmission frequency allocated to the first node.

39. The method of claim 34, wherein the at least one frequency wherein the first node can transmit a request signal is a different frequency from the least one frequency allocated to the first node for transmitting said data.

40. The method of claim 34, wherein said data is transmitted from the first node in the at least one frequency allocated to the first node for transmitting data.

41. The method of claim 1, wherein said second signal transmitted to the first node includes information relating to at least one timeslot allocated to the first node for transmitting data.

42. The method of claim 1, wherein the first node transmits within the at least one frequency which is timeslotted, wherein the first node is at least in part identified by the at least one frequency the first node is transmitting over and at least in part identified by the at least one timeslot the first node is transmitting in.

43. The method of claim 1, wherein randomly generated information is transmitted between the communication controller and the first node.

44. The method of claim 43, wherein said randomly generated information may be generated by the first node.

45. The method of claim 43, wherein said randomly generated information is randomly generated identified information.

46. The method of claim 43, wherein said randomly generated identification information is at least temporarily associated with the first node.

47. The method of claim 43, wherein said randomly generated information is time derived identifying information which is at least temporarily associated with the first node.

48. The method of claim 43, wherein said second signal transmitted from the communication controller to the first node includes randomly generated information generated by the first node, said randomly generated information by the first node having been previously transmitted from the first node to the communication controller.

49. The method of claim 43, further comprising the step of: transmitting node identification information from the first node to the communication controller subsequent to the first node receiving said randomly generated information from the communication controller.

50. The method of claim 1, wherein the data transmitted by the first node comprises an amount of data comprising at least one data packet, wherein said at least one data packet comprises information relating to a number of related data packets making up the data transmitted by the first node.

51. The method of claim 50, wherein the information relating to the number of related packets is a countdown value.

52. The method of claim 50, wherein the last data packet of the amount of data transmitted by the first node contains information indicating that the last data packet is the final data packet.

53. The method of claim 1, wherein a communication controller comprises a data communication device capable of receiving and transmitting signals to at least one other data communication device over a variable number of frequencies.

54. The method of claim 53, wherein said at least one other data communication device comprises at least one node.

55. The method of claim 1, wherein the first signal transmitted from the communication controller to the at least one network node including the first node is transmitted on a common control channel, wherein said common control channel is at least one timeslot within at the least one frequency wherein the communication controller transmits information to at one network node including the first node regarding random access timeslot request opportunities.

56. The method of claim 1, wherein the request signal transmitted from the first node to the communication controller is transmitted on a common control channel, wherein said common control channel is at least one timeslot within the at least one frequency wherein at least one network node including the first node may transmit a random access request signal.

57. The method of claim 1, wherein the second signal is transmitted from the communication controller to the first node on a common control channel, wherein said common

control channel is at least one timeslot within at least one frequency wherein the communication controller transmits timeslot assignment information.

58. The method of claim **1**, wherein the first signal is a recurring signal transmitted from the communication controller to at least one network node,

wherein transmissions between the communication controller and a plurality of network nodes may occur simultaneously,

wherein the state of operation for each relative node of the plurality of nodes comprises at least a first state for monitoring for a first signal from the communication controller, at least a second state for transmitting a request signal from the relative node to the communication controller, at least a third state for monitoring for a second signal from the communication controller and at least a fourth state for transmitting data, and

wherein the relative state for each relative node from the plurality of nodes is determined by the associated state of operation for each relative node.

59. The method of claim **58**, wherein each relative node from the plurality of nodes may operate at a different relative state of operation for each relative node in relation to other nodes from the plurality of nodes.

60. The method of claim **58**, wherein the state of operation for each relative node comprises at least one other state for receiving incoming data transmissions from the communication controller.

61. The method of claim **60**, wherein a node may operate in more than one state at any given period.

62. The method of claim **58**, wherein the state of operation also comprises at least one other state for receiving data transmissions from the communication controller.

63. The method of claim **62**, wherein a node may simultaneously send and receive transmissions.

64. The method of claim **58**, further comprising:

receiving an additional first signal transmitted from a communication controller at a second node, said additional first signal including information relating to the at least one frequency within which the second node may transmit an additional request signal to the communication controller,

transmitting the additional request signal from the second node to the communication controller within the at least one frequency, said additional request signal transmitted from the second node to the communication controller in response to the second node receiving the additional first signal;

receiving an additional second signal transmitted from the communication controller to the second node, said additional second signal from the communication controller being transmitted in response to the communication controller receiving the additional request signal from the second node, said second signal granting the second node permission to transmit additional data to the communication controller; and

transmitting the additional data from the second node to the communication controller.

65. The method of claim **64**, wherein the transmissions from and subsequent signal receptions by the second node may occur at any time after the communication controller has transmitted the first signal to the first node, including at least any time prior to the communication controller receiving all the data transmitted from the first node.

66. The method of claim **64**, wherein the at least one frequency used for transmission between the communication controller and the second node is timeslotted.

67. The method of claim **64**, wherein at least one timeslot is assigned to the second node by the communication controller.

68. The method of claim **67**, wherein the at least one timeslot within the at least one frequency allocated by the communication controller to the second node is assigned within the additional second signal, said at least one timeslot is assigned exclusively to the second node.

69. The method of claim **66**, wherein the communication controller transmits said additional first signal to the second node within the at least one frequency; and;

wherein said additional first signal to the second node is transmitted within at least one timeslot within the at least one frequency.

70. The method of claim **66**, wherein said additional first signal to the second node includes information relating to at least one timeslot within the at least one frequency wherein the second node may transmit said additional request signal.

71. The method of claim **66**, wherein the at least one frequency wherein the second node transmits said additional request signal is timeslotted; and

wherein said additional request signal from the second node is transmitted within at least one timeslot within at least one frequency.

72. The method of claim **64**, wherein said additional first signal transmitted from the communication controller to the second node is transmitted in at least one timeslot assignment frequency.

73. The method of claim **64**, wherein said additional request signal from the second node includes a request for transmitting a specified amount of data from the second node to the communication controller.

74. The method of claim **73**, wherein the communication controller transmits said additional second signal on the at least one timeslot assignment frequency which is timeslotted; and

wherein said additional second signal transmitted from the communication controller is transmitted within at least one timeslot within the at least one timeslot assignment frequency.

75. The method of claim **64**, wherein the second node is at least in part identified by the at least one frequency the second node is transmitting over and at least in part identified by the at least one timeslot the second node is transmitting in.

76. The method of claim **64**, wherein randomly generated information is transmitted between the communication controller and the second node; and

wherein said randomly generated information is randomly generated identification information.

77. The method of claim **76**, wherein said randomly generated information is time derived identifying information which is at least temporarily associated with the second node.

78. The method of claim **76**, wherein said additional second signal transmitted from the communication controller to the second node includes randomly generated information generated by the second node, said randomly generated information by the second node have been previously transmitted from the second node to the communication controller.

79. The method of claim **76**, further comprising the step of: transmitting node identification information from the second node to the communication controller subsequent to the second node receiving said randomly generated information from the communication controller.

80. The method of claim **64**, wherein the second node receives information transmitted from the communication controller relating to the at least one data transmission

frequency the second node must utilize in transmitting additional data to and receiving data from the communication controller.

81. The method of claim **80**, wherein the second node receives information from the communication controller relating to the at least one data transmission frequency wherein the second node is assigned to transmit the additional data.

82. The method of claim **81**, wherein the second node receives information from the communication controller relating to an assignment of at least one timeslot within the at least one data transmission frequency wherein the second node is assigned to transmit the additional data.

83. The method of claim **64**, wherein any number of frequencies may be used for transmissions between the communication controller and the second node.

84. The method of claim **83**, wherein the number of frequencies used for transmissions between the communication controller and the second node are varied.

85. The method of claim **1**, wherein the first node includes a writing pad for entering the data into the node.

86. The method of claim **85**, wherein the writing pad is pressure sensitive.

87. The method of claim **1**, wherein the first node receives information transmitted from the communication controller relating to at least one data transmission frequency the first node must utilize in transmitting data to and receiving data from the communication controller.

88. The method of claim **87**, wherein the first node transmits within at least one timeslot within at least one frequency.

89. The method of claim **87**, wherein the first node receives information relating to at least one monitor frequency wherein the first node must monitor for transmissions from the communication controller.

90. The method of claim **89**, wherein the at least one data transmission frequency wherein the first node transmits and the at least one monitor frequency wherein the first node receives transmissions from the communication controller comprises at least one range of frequencies utilized by the first node in transmitting data to and receiving transmissions from the communication controller.

91. The method of claim **89**, wherein the first node transmits data to and receives data from the communication controller via at least one antenna.

92. The method of claim **91**, wherein the at least one antenna comprises multiple antennas.

93. The method of claim **87**, wherein the at least one frequency comprises a list of frequencies the first node must utilized in transmitting data to and receiving data from the communication controller.

94. The method of claim **87**, wherein the at least one frequency comprises a range of frequencies wherein the first node must utilize in transmitting data to and receiving data from the communication controller.

95. The method of claim **87**, wherein the at least one data transmission frequency utilized in transmitting data from the first node to the communication controller can be changed.

96. The method of claim **87**, wherein the first node determines which of the at least one data transmission frequencies the first node will utilize in communicating with the communication controller.

97. The method of claim **96**, wherein the first node determines whether switching of the at least one data transmission frequency is required based upon signal quality.

98. The method of claim **87**, wherein the communication controller controls whether switching of the at least one data transmission frequency is required based upon signal quality.

99. The method of claim **87**, wherein the communication controller assigns the at least one data transmission frequency for the first node to utilize in communicating with the communication controller.

100. The method of claim **99**, wherein the communication controller assigns the at least one data transmission frequency to the first node for frequency switching.

101. The method of claim **100**, wherein the first node is assigned at least one timeslot within the at least one data transmission frequency by the communication controller to transmit.

102. The method of claim **1**, wherein any number of frequencies may be used for transmissions between the communication controller and the first node.

103. The method of claim **102**, wherein a number of frequencies used for transmissions between the communication controller and the first node are varied.

104. The method of claim **1**, wherein the communication controller maintains radio resources allocated to the first node after the data from the first node has been received, wherein said radio resources comprise at least one timeslot assigned to the first node for the first node to further communication with the communication controller, wherein said at least one timeslot is assigned to the first node at any time, wherein the communication controller may remove the at least one timeslot assigned to the first node when the at least one timeslot assigned to the first node is unused by the first node for a predetermined period of time.

105. The method of claim **1**, wherein the first node communicates with at least one data communication device via at least one antenna via at least one frequency.

106. The method of claim **105**, wherein the at least one antenna comprises multiple antennas and wherein the at least one frequency comprises multiple frequencies.

107. The method of claim **106**, wherein said multiple antennas comprises multiple antennas for transmitting signals from the first node to at least one data communication device and at least one antenna for receiving signals from the at least one data communication device.

108. The method of claim **106**, wherein said multiple antennas comprises at least one antenna for transmitting signals from the first node to at least one data communication device and multiple antennas for receiving signals from the at least one data communication device.

109. The method of claim **105**, wherein said at least one data communication device comprises multiple data communication devices, and wherein said at least one frequency comprises multiple frequencies.

110. The method of claim **106**, wherein the first node may transmit signals and receive signals simultaneously.

111. The method of claim **110**, wherein the first node may simultaneously transmit signals on multiple frequencies, and wherein the first node may simultaneously receive transmissions on multiple frequencies.

112. The method of claim **111**, wherein the first node may transmit the request signal to at least one data communication device while transmitting the data.

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